PN-ABI-948

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

Under contract to USAID, Bureau of Science and Technology, Office of Agriculture
Project Office: Hampden Square, 4800 Montgomery Lane, Suite 500, Bethesda, MD 20814
Telephone: (301) 913-0500 • Telex: 312636 • Fax: (301) 652-7530 • Fax: (301) 652-7791

AGRICULTURAL AND NATURAL RESOURCES POLICY ANALYSIS COURSE

The Policy Analysis Matrix (Agricultural Price Policy)

Methods and Guidelines No. 401

Volume 1

Prepared for: Agricultural Policy Analysis Project, Phase II (APAP II)
AID Contract No. DAN-4084-Z-00-8043-00

Author: Carl Gotsch

Prime contractor: **Abt Associates, Inc.**, 55 Wheeler Street, Cambridge, MA 02138 • (617) 492-7100

Subcontractors:

Harvard Institute for International Development, Harvard University, One Eliot Street, Cambridge, MA 02138 • (617) 495-2164
Food Research Institute, Stanford University, Stanford, CA 94305-6084 • (415) 723-3941
North Carolina State University, Department of Economics and Business, Box 7645, Raleigh, NC 27695-7645 • (919) 737-7187
Abel, Daft & Earley, 1410 King Street, Alexandria, VA 22314 • (703) 739-9090
International Science and Technology Institute, 1129 20th Street, NW, Suite 800, Washington, D.C. 20036 •(202) 785 0831
International Food Policy Research Institute, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036 • (202) 862-5600

BEST AVAILABLE COPY

TABLE OF CONTENTS

PREFACE iii

CHAPTER 1: DEVELOPING SINGLE COMMODITY FARM BUDGETS 1
COMPONENTS OF THE BUDGET 1
ORGANIZING THE SPREADSHEET--THE DIAMONDBACK METHOD 1
COMPUTING A SINGLE COMMODITY BUDGET 2
SUMMARY 8

CHAPTER 2: MULTIPLE RICE PRODUCTION SYSTEMS 11
ADDING PRODUCTION SYSTEMS TO THE WORKSHEET 11
CALCULATING COSTS AND REVENUES 12
GRAPHING REVENUES, COSTS AND PROFITS 13
SENSITIVITY ANALYSIS 15

CHAPTER 3: MULTIPLE COMMODITY BUDGETS 20
ADDING MORE COMMODITIES TO THE WORKSHEET 20
CALCULATING RELATIVE PROFITS 22
SENSITIVITY ANALYSIS 22

CHAPTER 4: FARM BUDGETS AT SOCIAL PRICES 28
EXPANDING THE EXISTING WORKSHEET 28
SOCIAL PROFITABILITY CALCULATIONS 29

CHAPTER 5: THE POLICY ANALYSIS MATRIX 32
A BRIEF INTRODUCTION TO PAMS 32
CREATING A PAM FOR HIGH PRODUCTIVITY, WET SEASON PADDY 35
CREATING MUNGBEAN PAMS 37
ADDING A PAM FOR MAIZE 38
COMPUTING SUMMARY RATIOS 38
SENSITIVITY ANALYSIS 41

CHAPTER 6: ESTIMATING SOCIAL PRICES 44
SOCIAL PRICES FOR TRADABLE GOODS 44
DETERMINING IMPORT PARITY PRICES 47
DETERMINING EXPORT PARITY PRICES 50
LINKING TABLES IN THE WORKSHEET 51
SUMMARY 53

CHAPTER 7: COMPUTING ADDITIONAL PARITY PRICES 55
IMPORT PARITY PRICES 55
EXPORT PARITY PRICES 55
NON-TRADED GOOD PRICES 58

CHAPTER 8: ANALYSIS OF NONTRADABLE SERVICES 59

DECOMPOSING TRACTOR COSTS 59
LINKING TABLES IN THE WORKSHEET 60
SUMMARY 63

CHAPTER 9: INCLUDING CAPITAL RECOVERY COSTS 64
ADJUSTING THE I-0 TABLE 64
THE CAPITAL RECOVERY COST TABLE 65
ADJUSTING THE PRIVATE AND SOCIAL BUDGETS 67
ADJUSTING THE PAMS 68
SUMMARY 68

CHAPTER 10: SENSITIVITY TO MACROECONOMIC ASSUMPTIONS 70
PRIVATE PRICES AND POLICY ANALYSIS 70
LINKING TABLES IN THE WORKSHEET 72
CREATING AND INTEGRATING THE ASSUMPTIONS TABLE 72
ASSESSING THE IMPACT OF A DEVALUATION ON MAIZE 73
FINAL COMMENTS REGARDING THE DIAMONDBACK METHOD 75

PREFACE

The computer exercises in this volume serve two purposes. The most important is substantive. They provide an introduction to the policy analysis matrix (PAM) approach to analyzing government policy interventions in the agricultural sector. The analytical framework for the analysis draws upon the seminal work by Monke and Pearson, *The Policy Analysis Matrix in Agricultural Development.* The Monke-Pearson text should be used in conjunction with the exercises developed here.

The workbook also seeks to develop microcomputer skills. Particular attention is given to the efficient arrangement of computations on the spreadsheet which simplifies the expansion from a single commodity PAM to a PAM that simulates a farming system. Moreover, careful application of a few simple rules allows PAM's from one country or region to be copied for reuse in other situations. They become, in spreadsheet jargon, "templates" for further work.

Students who find they have difficulty in following this manual's spreadsheet commands may find it helpful to work through the first few chapters of one of the many beginning books on learning Lotus. An excellent introduction is contained in *Learning Lotus 1-2-3* from Lotus Development Corporation. A more helpful reference volume is *The Best Book of Lotus 1-2-3, Rel. 2.2* by Alan Simpson. It can be obtained from Macmillian Publishing Company.

This volume begins by developing a single commodity farm budget using private or market prices. Chapters 2 and 3 extend the budgeting exercise to encompass increasingly more complex multiple commodity systems. Chapter 4 illustrates the creation of commodity budgets using social prices, without actually describing how to calculate such prices. Chapter 5 introduces the Policy Analysis Matrix (PAM) and links the PAM to previously completed budgeting exercises. Chapters 6 and 7 explain the process for calculating export and import parity (social) prices for tradable inputs and outputs. Decomposition of non-tradable services used in production, such as tractors, is covered in Chapter 8. Chapter 9 suggests a method for including capital recovery costs in the overall analysis. Finally, Chapter 10 gives an example of sensitivity analysis on macroeconomic variables.

A number of people have contributed to the development of this manual. Much of the first draft, based on Indonesian data, was written by Rosamund Naylor. This material was subsequently revised in the light of Scott Pearson's "beta testing." Brigit Helms extended the final chapters to include material on alternative macro policy assumptions. Manny Gaspay was responsible for converting the earlier Indonesian examples to the Philippine data on which the present version is based. Bugs undoubtedly remain and comments on the manual are welcome.

Thanks are due to the Agricultural Policy Analysis Project (APAP), funded by U.S.A.I.D., for providing the resources to prepare this manual. Further information about this project, its newsletter and its published output in the agricultural policy field can be obtained from Abt Associates, Inc., Hamden Square, 4800 Montgomery Lane, Suite 600, Bethesda, MD 20814.

Carl H. Gotsch
July, 1991

CHAPTER 1: DEVELOPING SINGLE COMMODITY FARM BUDGETS

Farm level commodity budgets are the building blocks of the PAM approach to agricultural policy analysis. This chapter reviews the basic components of farm budgets and shows how to calculate private profitability for a single commodity. Data on high yielding paddy in the Philippines are used to illustrate the computations.

COMPONENTS OF THE BUDGET

Chapters 8 and 9 of the Monke and Pearson text contain a detailed discussion of the intricacies of developing farm budgets.[1] This exercise covers the basic ingredients of M-P's farm budgets, i.e., tradable inputs, domestic factors, outputs, and prices. The discussion in Chapter 9 ("Farm Level Budgets and Analysis") is essential reading before undertaking the data collection that precedes the construction of actual budgets.

The main data components of a commodity budget are:

(1) Tradable intermediate inputs -- (fertilizer, seeds, pesticides)
(2) Factor inputs -- (land, labor, and capital) [2]
(3) Outputs -- (crops and by-products)
(4) Prices of inputs and outputs

Quantities are standardized on land area, e.g., man-hours/ha for labor, kg/ha for fertilizer, and kg/ha for yields. Prices are specified in corresponding measurements, e.g., P/hour for labor, P/kg for fertilizer, and P/kg for output. Profits are calculated by subtracting the costs of tradable inputs and factor inputs from total revenue.

ORGANIZING THE SPREADSHEET--THE DIAMONDBACK METHOD

Spreadsheets for farm budgets may be organized in a variety of ways. The method used here begins with an input-output data table of physical quantities, adds a data table of prices, and produces a third (budget) table with computations that draw on the first two tables.

Complicated worksheets such as the ones developed in this manual often utilize the so-called **"diamondback"** method which arranges tables along the spreadsheet's diagonal. This procedure facilitates organizational flexibility. So long as the table rows and columns do not overlap, it is possible to alter the table structure while leaving the basic relationships of the spreadsheet intact. **Formulas, functions and range names continue to be valid if rows and columns are "inserted" and "deleted" rather than added or erased.**

This chapter applies the diamondback method for organizing the spreadsheet by placing the

---

[1] Monke and Pearson text will be referred to in the manual as M-P.

[2] Factor inputs are often called "domestic resources." The two terms will be used interchangeably in the exercises that follow.

Input-Output table in the top left-hand corner, the Price table below and to the right of the Input-Output table, and the Budget table below and to the right of the Price table. Figure 1.1 illustrates this format. The tables are identical except for the measurements (e.g., labor quantity equals Hr/ha, labor price equals P/ha). Using identical formats makes it easy to develop a third table that contains the commodity budget. Once the formula (price times quantity) for the first cell has been entered, the *Copy* command can be used to calculate all of the remaining cells in the budget table. Individual input costs can be summed to calculate total cost.

With a diamond array it is highly desirable to use the ***Range Name*** command to identify the tables. By using table names, along with the **GoTo** [F5] and **Names** [F3] function keys, tables located anywhere on the spreadsheet can be found quickly and easily.

COMPUTING A SINGLE COMMODITY BUDGET

The first step in creating a spreadsheet is to specify the labels and column headings. After the table structure has been designed, it can be copied to other tables. If this sequence is followed, changes can be made in the spreadsheet's structure without having to re-type the data.

Input-Output Table

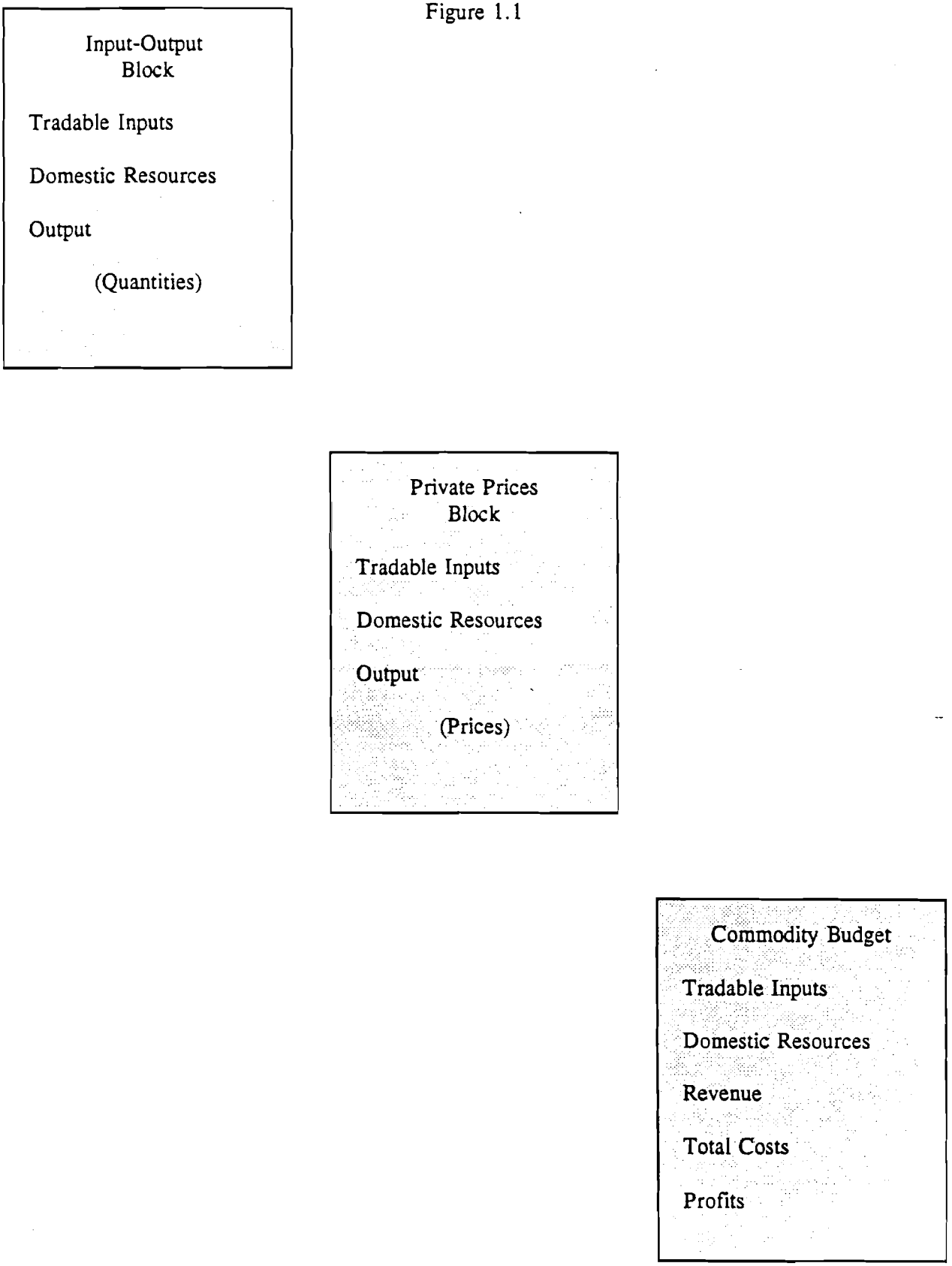
Move to the top of the spreadsheet and type a name (I-O) in Column A. Begin typing the list of input quantities in column B as illustrated in Screen 1.1. The level of disaggregation will depend on the type of data that are available. It is usually best to disaggregate as much as possible to facilitate sensitivity analysis. Remember to specify carefully units of measurement, e.g., kg/ha for fertilizer, hours/ha for labor, etc. Make sure to expand the width of column B to accommodate all labels by using the */Worksheet Column Set-Width* command. Put a double at line at the bottom of the table to show clearly where the table ends.

Assign a name to the Input-Output table with the ***Range Name*** command. To do this,

Move to:	the top left corner of the table, i.e., the "I-O" cell address.
Press:	/
Select:	***Range***
	Name
	Create
Type:	***I-O***
	[Enter]

Select the entire table range to facilitate subsequent spreadsheet manipulation and printing.

Figure 1.1


Input-Output Block
Tradable Inputs
Domestic Resources
Output
(Quantities)
Private Prices Block
Tradable Inputs
Domestic Resources
Output
(Prices)
Commodity Budget
Tradable Inputs
Domestic Resources
Revenue
Total Costs
Profits

Screen 1.1: Physical Input-Output Table

	A	B	C	D
1	I-O		High Yielding Paddy	
2		Quantities	Wet	Dry
3				
4	Tradables:	Fertilizer (kg/ha)		
5		Urea	162	192
6		0-18-0	165	196
7		Chemicals (kg/ha)	8	8
8		Seed (kg/ha)	115	115
9		Fuel (liters/ha)	64	256
10				
11	Factors:	Labor		
12		Seedbed preparation	87	104
13		Crop care	250	240
14		Harvesting	116	125
15		Threshing	12	14
16		Drying	54	49
17				
18		Capital		
19		Working capital (P/ha)	5,519	7,365
20		Tractor services (hr/ha)	140	180
21		Thresher (hr/ha)	95	112
22				
23		Land (ha)	1	1
24				
25	Output:	(Kg/ha)	5,500	6,500
26				
27				

Price Table

After creating the Input-Output table, build the Prices table below and to the right of the I-O table. The Prices table should be placed so that at least a column and a row separate it from the Input-Output table. The Price table can be created by copying the structure of the Input-Output table and by editing the unit measurements, e.g., by changing kg/ha to P/kg.

Move to the top of the Input-Output table.
Press: /
Select: *Copy*

"Enter range to copy from A1 . . A1"
Move the cursor down and across the table, including the double dotted line at the bottom of the table and press **[Enter]**.

"Enter range to copy to A1 . .

Move down and to the right of the Input-Output table's bottom line, leaving one empty column and one empty row. Press **[Enter]**.

A copy of the I-O table will be inserted along the diagonal.

Move to the copied I-O table and edit it so that it becomes the Price table. First, put the cursor on the copied cell containing term: "I-O" and type "P-Prices" for *private prices*. Enter a return. Use the */Range/Name/Create* command (see the instructions for the I-O table above) and create a range called "P-Prices."

Edit the remainder of the Price table so that the prices of the inputs and output are shown instead of physical quantities (Screen 1.2.)[3] Even in the case when input and output prices for wet and dry season paddy are identical (in our example they are not, land rent and paddy price are higher in the dry season), two price columns should be used in order to retain the symmetry of construction between the I-O and Price tables. The reasons for this redundancy will become apparent in the following section.

Use the edit key **[F2]** to change the measurements, e.g., kg/ha to P/kg for fertilizers. After editing each measurement, press **[Enter]**.

Type **Private Prices** over the word **Quantities** at the top of the table.
In the "**Output**" row, convert **(kg/ha)** to **(P/kg)**.

---

[3] Caution: The price of working capital (percentage) is entered in the price table in decimal format instead of percentage format for uniformity, since all the rest of the prices are in decimals. Lotus 1-2-3, however, offers the option of percentage formatting for individual cells or ranges.

Screen 1.2: Private (Domestic) Prices Table

	F	G	H	I
28	P-Prices		High Yielding Paddy	
29		Private Prices	Wet	Dry
30				
31	Tradables:	Fertilizer (P/kg)		
32		Urea	3.8	3.8
33		0-18-0	2.3	2.3
34		Chemicals (P/kg)	120.0	120.0
35		Seed (P/kg)	6.0	6.0
36		Fuel (P/liters)	6.7	6.7
37				
38	Factors:	Labor (P/man hour)		
39		Seedbed preparation	7.5	7.5
40		Crop care	6.2	6.2
41		Harvesting	6.2	6.2
42		Threshing	7.0	7.0
43		Drying	6.2	6.2
44				
45		Capital		
46		Working capital	.14	.14
47		Tractor services (P/hr)	6.50	6.50
48		Thresher (P/hr)	12.50	12.50
49				
50		Land (P/ha)	3,500.00	7,100.00
51				
52	Output:	(P/kg)	4.5	4.8
53				
54				

Enter the data shown in Screen 1.2 by typing over the entries in the copied I-O screen.

Budget Table

Create a third table to calculate costs, revenue, and profits. This table has the same table format as the previous tables, and can be built by using the ***Copy*** command. The calculations in the budget table are obtained by multiplying quantities and prices.

Copy the table format from the P-Price table, including the double dotted line at the bottom, to a position below and to the right. Type "P-Budget" over the term "P-Price" and use the ***/Range Name Create*** command to create a range called "P-Budget." Compute the entries in the budget table with the following steps:

Step 1.

Input costs, domestic factor costs and revenue for one hectare are computed by multiplying quantities in the I-O table by prices in the price table. Remember to start the formula with a + sign. The formula can be written using **relative** cell addresses.[4] For example, to calculate the cost of urea in the wet season,

Type: +
Move to: **Urea** in the wet season in the Input-Output table
Type: *
Move to: **Urea** in the wet season in the Price table
Press: **[Enter]** [5]

The cells for urea price and quantity can be identified quickly within the spreadsheet by using the **[F5]** and **[F3]** keys and choosing the appropriate table.

Step 2.

The formula can now be copied from the urea cell to all of the other input cells as well as the Total Revenue cell in the budget table with the ***Copy*** command. To suppress the zeros that appear in this process, use the ***/Worksheet Global Zero Yes*** command.

---

[4] Recall that when a *relative* cell address is copied, the *relationship* between the cells positions that make up the original formula are preserved. The *absolute* cell address sign ($) fixes the relationship so that the formulas, when copied, continue to refer to the original cells. *Absolute* address can be fixed by row (A$1), by column ($A1) or both ($A$1). Copying a cell with a fixed row address, for example, means that the relationship between columns will change, but the row portion of the formula will remain that same.

[5] An alternative to the "pointing" approach is simply to note the appropriate cells for urea price and quantity on a piece of paper before calculating the cost, then write the formula directly into the spreadsheet. For example, if the urea quantity is in cell C7 and the urea price is in cell G35, the formula to be typed into the budget cell for urea is +C7*G35/1000.

Screen 1.3: Private Prices Budget

	K	L	M	N
55	P-Budget		High Yielding Paddy	
56		Cost and Returns (P/ha)	Wet	Dry
57				
58	Tradables:	Fertilizer (P/kg)		
59		Urea	616	730
60		0-18-0	379	451
61		Chemicals (P/kg)	960	960
62		Seed (P/kg)	690	690
63		Fuel (P/liters)	429	1,715
64				
65	Factors:	Labor (P/man hour)		
66		Seedbed preparation	653	780
67		Crop care	1,550	1,488
68		Harvesting	719	775
69		Threshing	84	98
70		Drying	335	304
71				
72		Capital		
73		Working capital (P/ha)	773	1,031
74		Tractor services (P/hr)	910	1,170
75		Thresher (P/hr)	1,188	1,400
76				
77		Land (P/ha)	3,500	7,100
78				
79	Output:	Total Revenue	24,750	31,200
80		Total Costs (excluding land)	9,285	11,592
81		Profit (excluding land)	15,465	19,609
82		Net Profit (including land)	11,965	12,509
83				

Type: /**WGZY**

Care must be taken to be sure that the row structure is the same for all tables. Lotus does not recognize row labels when multiplying. When relative cell addresses have been specified, it simply matches rows by their position.

Step 3.

Move to the new budget table and use the edit key **[F2]** to edit the table labels as shown in Screen 1.3. Then add the total cost, profit, and net profit rows in the following manner:

Step 3.1. Insert a row below **Total Revenue** and label it **Total Costs (Excluding Land)**. This entry sums all individual costs except for land. Compute total Costs with @SUM(..). The appropriate range, in this case, is all costs above the total land costs line.

Step 3.2. Insert a row below Land Cost and label it **Profit (Excluding Land Costs)**. This cell is calculated by subtracting the previously computed Total Costs row from Total Revenue.

Step 3.3. Insert a row below Profit and label it **Net Profit (Including Land)**. This cell is calculated by subtracting the Land Cost row from the Profit Excluding Land Cost row.

The distinction between profits that include or exclude returns to land is important. Whereas rental values can be observed and included in a private budget, the same is not true for social budgets. As M-P (pp. 207-209) make clear, social prices of factors uniquely fixed to agriculture are not observable, and consequently other methods must be used to find a social value for them.

You may wish to present the results of the calculations in a format other than the default format, which in this case may lead to some numbers with more than 2 decimal places. To achieve the format seen in Screen 1.3, do the following:

Press:	/
Select:	**Range, Format, Fixed**
Type:	**1** (when prompted for the number of decimal places)
Move to:	Urea in the wet season in the Budget table (Cell address M71)
Move to:	Land Cost in the dry season (Cell address N92)
Press:	**[Enter]**

These steps will format the costs as a number with one decimal place. To present the rest of the results in a "comma" format with no decimals, select , instead of **Fixed** and enter **0** when prompted for the number of decimal places.

Save the just completed exercise under the name CHAPT1. Use */File Save*, then type CHAPT1. If you have saved the chapter previously under this name, you will be asked: "Cancel, Replace,

Backup"). Choose "Replace." This will cause Lotus 1-2-3 to write the current contents of the spreadsheet over the previous file. Lotus will automatically add the .WK1 suffix to the file name, calling it CHAPT1.WK1.

Then save the worksheet a second time. This time choose "Backup" instead of "Replace." This will create a duplicate of CHAPT1.WK1 called CHAPT1.BAK. Use CHAPT1.WK1 to continue the exercise in Chapter 2. If a serious error is made, return to the original by retrieving CHAPT1.BAK. Using a backup copy of the original may save redoing a substantial amount of work.

SUMMARY

Chapter 1 organizes the ingredients of a simple commodity budget. The exercise demonstrates how to arrange the computations and take advantage of the power of the ***Copy*** command. The ***Copy*** command replicates the structure of the input-output table to produce the price and budget tables. Only a minor editing of measurement units is needed to produce the new tables. The ***Copy*** command is then used to reproduce the formulas that compute the values in the individual commodity budget table. The addition of several rows to the commodity budget permits the calculation of profits excluding land costs by subtracting total costs excluding land costs from total revenue. Subtraction of the land costs from this figure yields net profits.

The values obtained in the private budget calculation translate into the first row of the PAM, which describe private profitability. In Chapter 4, this row of the PAM will be juxtaposed with the calculation of profits at social prices. The two rows form the basis of further calculations that yield various protection coefficients and estimates of the incidence and degree of policy interventions and market imperfections.

CHAPTER 2: MULTIPLE RICE PRODUCTION SYSTEMS

Chapter 1 calculated a single commodity budget for high productivity paddy production in the Philippines. This chapter includes additional paddy production systems in the spreadsheet and calculates private profits for each system. Sensitivity analyses also are carried out on several input-output and price coefficients.

The most important objective of the chapter is to demonstrate how to expand commodity budgets within the diamondback method. This approach to worksheet design encourages an analytical strategy that begins simply but becomes progressively more complex as the policy analyst acquires more information.

ADDING PRODUCTION SYSTEMS TO THE WORKSHEET

Retrieve the copy of the worksheet completed in Chapter 1 using the ***File Retrieve*** command. GoTo the input-output table (I-O) by pressing [F5] and [F3] and selecting **I-O**. (Pressing [F3] a second time produces a *table* of range names from which to choose.)

If you have not created names for your tables, return to Chapter 1 and complete that part of the exercise. All subsequent directions assume that the tables have been named correctly.

Adding Production Systems to the I-O Table

Expand the I-O table by inserting columns to the right of the existing dry season high-productivity crop. Use the ***Worksheet Insert Column*** command and insert three columns after the last column in this table. Title the first two columns: Average Yield Paddy with sub-titles of Wet and Dry (seasons). Title the third new column: Rainfed Paddy. When completed, the table should look like Screen 2.1.

Physical data for average-productivity and rainfed paddy are shown in Table 2.1. Note that rainfed paddy does not utilize any gasoline input. Gasoline or diesel fuel is required to operate the irrigation pump, tractor, and power thresher. Fuel used by the tractor and thresher, however, are supplied by the rental operators of these farm machineries and its cost is included in their rental rates. Fuel for the farmer-owned irrigation pump, on the other hand, must be accounted for as a tradable input in irrigated paddy production. The data represent rice growing environments distinguished by different soil types, water control methods and drainage regimes. They are **not** assumed to be different technologies for growing rice under the same environmental conditions. The data should be typed into the columns inserted in the expanded I-O table.

Adding Production Systems to the Prices Table

Add 3 columns to the Prices table using the same procedure followed for the I-O table. Tradable input prices and the prices of labor and capital are assumed to be the same for all paddy systems, so these prices should be copied into the columns for the new production systems. Wet and Dry season season paddy prices are the same as prices for the high yielding systems. Rainfed varieties are the same as the paddy grown in the wet season.

Screen 2.1: Physical Input-Output Table

	A	B	C	D	E	F	G
1	I-O		High Yield Paddy		Average Yield Paddy		Rainfed
2		Quantities	Wet	Dry	Wet	Dry	Paddy
3							
4	Tradables:	Fertilizer (kg/ha)					
5		Urea	162	192			
6		0-18-0	165	196			
7		Chemicals (kg/ha)	8	8			

Although private prices for the new paddy systems are the same as for the original high yielding systems, it would be reasonable to expect the rental prices of land to vary with the profits obtained from rice production. The land price for the wet season and the dry season in the average productivity paddy equals P2,380 and P5,000, respectively. The land price for rainfed paddy is P1,500.

Adding Production Systems to the Budgets Table

The budget calculations table, "P-Budget," must also be expanded to include the new columns that have been inserted in the I-O and Price tables.

CALCULATING COSTS AND REVENUES

The formulas for calculating costs in the expanded budget table have been adjusted automatically by Lotus for the changes made in the number of columns in the I-O table. Copy the formula for urea costs to the entire budget table down to and including the **Total Revenue** row with a single *Copy* command.

After copying formulas you may want to clear zeros once again: /WGZY.

Total Costs and Profits

All formulas have been automatically adjusted for the columns inserted in the I-O and Budget tables. They can simply be copied from the high yielding systems to the new systems that have been added to the spreadsheet. A completed Lotus budget table is shown in Screen 2.4.

GRAPHING REVENUES, COSTS AND PROFITS

One way to illustrate profits for a number of different technologies is to use a **stacked-bar** graph with land on the bottom, variable costs on the next level, and profits on the highest level.

This graph is useful because it shows all of the technologies side by side (Figure 2.1) and makes it possible for decision makers to grasp quickly relative profitability.

Screen 2.2: Graphing Relative Profits

	Q	R	S	T	U	V	W
78	----------						
79	Output:	Total Revenue	24,750	31,200	16,200	23,520	10,800
80		Total Costs (excluding land)	9,285	11,592	9,280	11,879	6,251
81		Profits (excluding land)	15,465	19,609	6,920	11,641	4,549
82		Net Profit (including land)	11,965	12,509	4,540	6,641	3,049
83			High-W	High-D	Avg-W	Avg-D	Rain
84	==========						

Before creating the graph, make a new row below **Net Profits** in the Budget table for the X-axis labels as shown in Screen 2.2. These labels will be an abbreviated version of the headings at the top of the table, for instance, **High-W** for High-Yielding Wet Season Paddy, **High-D** for High-Yielding Dry Season Paddy, **Avg-W**, etc. Short headings are required so that they all fit on the graph.

Now make the graph.

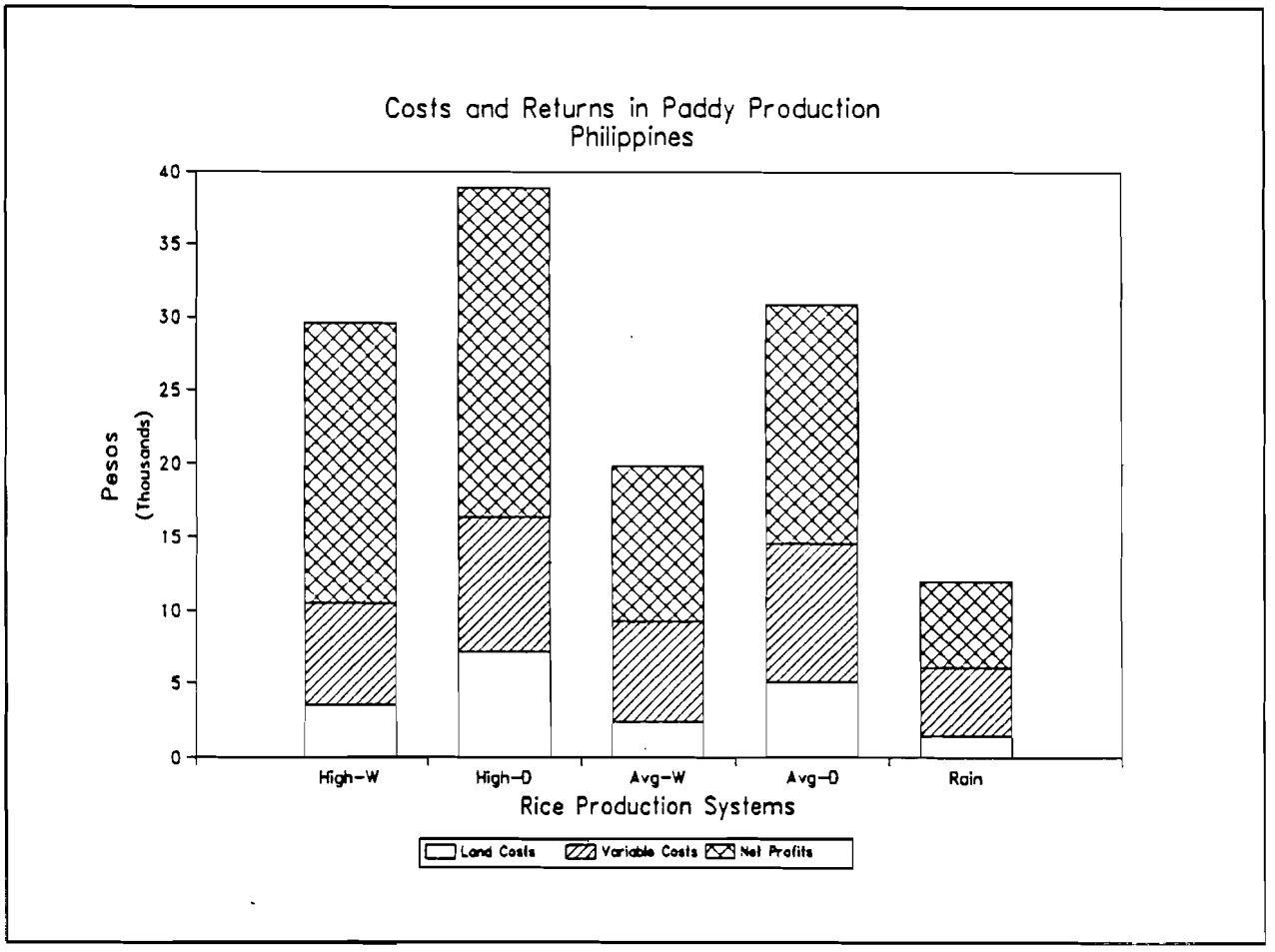
Press: /
Select: ***Graph***
Type
Stacked-Bar
X

Specify the row of labels, e.g., S110 . . W110
Press: **[Enter].**
Select: ***A***
Specify the row of Total Costs Excluding Land, S105 . . W105
Press: **[Enter]**

Select: ***B***
Specify the row of Land Costs, S101 . . W101
Press: **[Enter]**
Select: ***C***
Specify the row of Net Profits, S109 . . W109
Press: **[Enter]**

Name each of these ranges:
Select: ***Options***
Legend
Specify:
A: Cost Excluding Land
B: Land Costs

Figure 2.1: Costs and Returns in Paddy Production



C: Net Profit
Give the graph titles:
Select: ***Options***
Titles
Specify:
First: Costs and Returns in Paddy Production
Second: Philippines
X-axis: Rice Production Systems
Y-axis: Pesos

Select: ***Quit*** (move back to the main menu)

The graph can be viewed with the **View** command. If the graph is correct, save the graph file. Call the graph "Profit"; it will be saved as "PROFIT.PIC."

Before printing the graph, save the **worksheet file** containing the data on which the graph is based. Call it CHAPT2. Save it a second time and choose "Backup." After saving the file, exit 1-2-3. Enter the Print-graph program and print the graph using the **Image-Select** command.

SENSITIVITY ANALYSIS

Once data and formulas are entered into a worksheet, sensitivity analysis can be conducted with minimal effort. This exercise compares relative profitability across different paddy systems (technologies and seasons) under different pricing scenarios. This type of exercise helps policy-makers understand how input and output prices affect farm incomes and, hence, farmers' potential production responses.

One approach to performing a sensitivity analysis of price policies makes extensive use of named ranges. For example:

1) Move to the price table using the [**F5**] and [**F3**] keys.
2) Change the price(s) that are to be tested for sensitivity.
3) Move to the budget table using the [**F5**] and [**F3**] keys.
4) Move the cursor to the bottom of the table and look at the effects on Total Costs, Total Revenues, and Profits.

A more efficient way of doing interactive sensitivity analysis entails the use of spreadsheet *windows*. Put the cursor in the middle of the screen and type / ***Worksheet Windows Horizontal (/WWH)***. A bar will appear across the middle of the screen. Repeat the process, except this time select ***Unsynchronized***. Type: ***/WWU***. The diamondback structure requires unsynchronized movement in order to view two tables simultaneously in the windows.

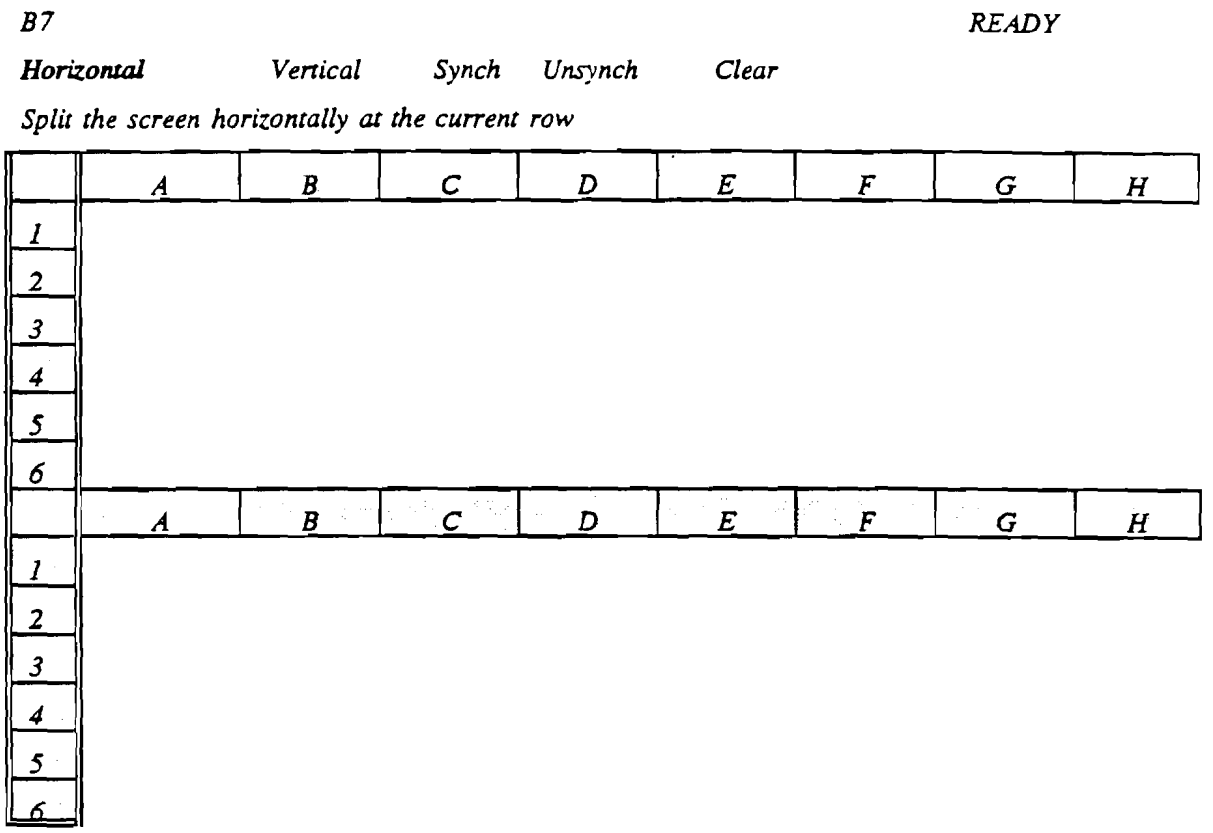
Use the [**F6**] key to move back and forth between the tables. Use [**F5**] and [**F3**] to select the Budget table in the bottom window and scroll until the rows for Total Costs, Total Revenues and Profits are in view. Then press [**F6**] to jump to the upper screen. Use [**F5**] and [**F3**] to go to the price table, P-Price. Scroll to the prices on which the sensitivity analysis is to be performed. Change the prices as desired, then press the recalculation key, [**F9**] and note the results in the lower window.

Print the results of the sensitivity analysis to facilitate comparisons between price assumptions. Compare with the original results in Screen 2.4.

Compare the relative profits for the different systems under the following conditions and make some notes in the space provided below regarding the results:

1) All fertilizer prices are doubled; eg., urea is raised from P3.20/kg to P6.40/kg.

Screen 2.3: Horizontal Windows



2) Fertilizer prices do not change but paddy price rises to P7.50/kg.

3) Same as above with paddy prices at:

   a) P10.00/kg

b) P3.75/kg

4) Fertilizer and output prices remain at their original values, but all labor costs double.

What are the policy implications of these results for farmer incentives? In many countries, different government agencies administer output and input prices. Note that the sum total of different prices policies determines farmer incentives to grow the crop--the farmer responds to changes in profitability, regardless of the source of these changes.

What can be said about the competitiveness of the various production systems? Significant private profits in a system means that rents accrue to the owners of domestic resources such as land. Recall that in a perfectly competitive system, there are no profits, i.e., in equilibrium, factors are paid the value of their marginal product. Consequently, positive profits imply low levels of competition.

Table 2.1: Input-Output Data for Alternative Paddy Systems

	High Yield Paddy		Avg. Yield Paddy		Rainfed
Quantity	Wet	Dry	Wet	Dry	Wet
Fertilizer					
Urea	162	192	224	230	167
0-18-0	165	196	100	120	20
Chemicals	8	8	8	7	2
Seed	115	115	100	115	115
Fuel	64	256	96	320	
Labor					
Seedbed	87	104	64	75	65
Crop care	250	240	152	175	100
Harvesting	116	125	196	210	200
Threshing	12	14	8	11	5
Drying	54	49	36	38	60
Capital					
Working capital	5,519	7,365	5,136	7,166	3,398
Tractor	140	180	240	260	140
Thresher	95	112	64	88	40
Land	1	1	1	1	1
Output	5,500	6,500	3,600	4,900	2,400

Screen 2.4: Paddy Budgets at Private Prices

	Q	R	S	T	U	V	W
55	P-Budget		High Yield Paddy		Avg. Yield Paddy		Rainfed
56		Cost and Returns (P/ha)	Wet	Dry	Wet	Dry	Wet
57							
58	Tradables:	Fertilizer					
59		Urea	616	730	851	874	635
60		0-18-0	379	451	230	276	46
61		Chemicals	960	960	960	840	240
62		Seed	690	690	600	690	690
63		Fuel	429	1,715	643	2,144	0
64							
65	Factors:	Labor					
66		Seedbed preparation	653	780	480	563	488
67		Crop care	1,550	1,488	942	1,085	620
68		Harvesting	719	775	1,215	1,302	1,240
69		Threshing	84	98	56	77	35
70		Drying	335	304	223	236	372
71							
72		Capital					
73		Working capital	773	1,031	719	1,003	476
74		Tractor services	910	1,170	1,560	1,690	910
75		Thresher	1,188	1,400	800	1,100	500
76							
77		Land	3,500	7,100	2,380	5,000	1,500
78							
79	Output:	Total Revenue	24,750	31,200	16,200	23,520	10,800
80		Total Costs (excluding land)	9,285	11,592	9,280	11,879	6,251
81		Profits (excluding land)	15,465	19,609	6,920	11,641	4,549
82		Net Profit (including land)	11,965	12,509	4,540	6,641	3,049
83			High-W	High-W	Avg-W	Avg-D	Rain
84							

CHAPTER 3: MULTIPLE COMMODITY BUDGETS

Farmers' decisions concern both input use and crop choice in each season. These decisions depend on the agroclimatic production zones and the technologies, including irrigation facilities, available to farmers. Within each season, differences in expected profitability influence the crop choice for a given production system.

Chapter 3 introduces several non-paddy crop alternatives. The issue of comparative advantage **within** a production environment becomes important in determining what commodities farmers will find profitable to produce. As a result, response to price changes, i.e., supply response, becomes more complex. A detailed discussion of the problems associated with modeling more complex commodity systems can be found on pp. 161-169 of the Monke and Pearson book.

Once the budgets for the non-paddy crops are constructed, sensitivity analysis can be performed to gauge the potential impact of policy prices on profitability **within** farming *systems*.

ADDING MORE COMMODITIES TO THE WORKSHEET

This section adds irrigated mungbeans, irrigated maize, and rainfed maize to the analysis. **The two irrigated crops are assumed to be grown in an average productivity agro-climatic environment during the dry season. Rainfed maize competes with rainfed rice.**

The diamond pattern of the worksheet permits the addition of new quantities and prices without interfering with existing tables and range name locators. If care is taken to insert rows and columns, existing range names do **not** have to be re-specified nor do most formulas have to be rewritten.

REMEMBER! New columns and rows must be inserted--not added--in order to insure that the existing tables do not overlap. Use */WIC* and */WIR* to insert columns and rows.

The first step is to call up the worksheet on paddy production systems from the previous exercise (CHAPT2.WK1).

Table 3.1 contains budget data for mungbeans and maize. This table is <u>not</u> a spreadsheet, so <u>do not</u> simply type it into your worksheet. The headings shown in the data table may be used as a guide to headings in the worksheet. The data can be added to the existing I-O and Prices tables by (1) expanding the size of the tables with the ***Worksheet Insert*** command, and (2) typing the data into the tables. Use the **[F5]** and **[F3]** keys to move from one table to the next.

Adding Data to Tables Using "Titles"

One problem in filling out the existing tables is that the input labels (fertilizer, labor, etc.) can not be seen from the new columns. This makes the process of data entry more difficult. The ***Titles*** command always displays the column of labels on the left regardless of which data columns appear

on the right.[6]

Begin by moving into the I-O table. Then,

Press: /
Select: *Worksheet*
Titles
Vertical

Move the cursor to the right until the new headings, "Irrigated Mungbeans" and "Irrigated Maize", appear on the right hand side of the screen, as shown in Screen 3.1.

Screen 3.1: Physical Input-Output Table

	A	B	H	I
1	I-O		Irrigated	Irrigated
2		Quantities	Mungbean	Maize
3	---	---	---	---
4	Tradables:	Fertilizer (kg/ha)		
5		Urea	162	192
6		0-18-0	165	196

Budget data can now be entered into the I-O table easily because the labels for the inputs are in view. Enter the budget data shown in Table 3.1. After the data have been entered, clear the title:

Press: /
Select: *Worksheet*
Titles
Clear

Follow the same procedure to modify the P-Price table.

CALCULATING RELATIVE PROFITS

Move to the budget calculation table. Notice that this table moved automatically as a result of additions to the I-O and price tables. All of the calculations moved to new columns, but the

[6] Alternatively, the *Windows* command learned in Chapter 2 could also be used. However, the *Titles* command is simpler for data entry tasks.

formulas changed automatically to reflect the insertions.

Insert three columns to the right of the "Rainfed Rice" column for "Irrigated Mungbeans", "Irrigated Maize", and "Rainfed Maize".

Sufficient space already exists to accommodate the headings for mungbeans and maize. These may either be copied from the I-O or Prices tables--or typed in.

The new budget values can now be copied for each of the production systems and commodities.

Step 1

Place the cursor on the urea cost cell in the first column of data. Use the ***Copy*** command to copy the formula contained in this cell to the entire data area down to and including **Total Revenue**.

Step 2

Copy the formulas for **Total Costs Excluding Land**, **Profits Excluding Land Costs**, and **Net Profits** into the new commodity columns. (Try copying all three rows in a single step.)

Compare your results to the completed budget table shown in Screen 3.3.

Update the graph produced in Chapter 2 to reflect the new commodities by simply adding additional labels, say, "Soy," "Maize," and "RMaize," and extending the ranges of the various rows to include the new commodities. See Figure 3.1.

Save the worksheet at this point. Call it CHAPT3. Save it a second time as CHAPT3.BAK by choosing "Backup." Do not exit Lotus 1-2-3.

SENSITIVITY ANALYSIS

As noted in a previous exercise, sensitivity analyses are best done using the *Windows* command. Remember to use the *Unsynchronized* command to get the relevant portions of both the price and budget tables on the screen at the same time. The effects of changes in assumptions on revenues, costs and profits can then be ascertained immediately.

Perform sensitivity analysis on all or some of the following parameters and make a note of any interesting results in the space provided:

a) fertilizer prices double

b) labor costs double

c) yields for mungbeans double

d) yields for corn double

e) paddy prices drop by 50%

Questions: Note that changes in the costs of inputs have much smaller effects on profits than changes in the prices of outputs? Why? What are the implications of this kind of sensitivity analysis for data collection efforts? If human resources to do research on agricultural policy are scarce, do these results suggest what types of empirical work a Ministry or planning unit ought to focus on?

Answers: Profits are much less sensitive to individual input prices than to individual output prices because each input makes up only a fraction of the cost. This strongly suggests that the highest priority in doing research is to obtain the best possible data on output prices and yields. The next highest priority would be the largest item in costs, say, labor. Only after the larger cost items have been determined should minor costs be investigated. The "what-if" feature of spreadsheets makes it possible to determine quickly exactly how much impact a particular price has on the overall results. Efforts to improve the database can be organized accordingly.

Screen 3.2: Data for Mungbean and Maize

Quantities	Irrigated Mungbeans	Irrigated Maize	Rainfed Maize	Units	Prices
Fertilizer					
Urea	25	100	85	P/kg	3.8
0-18-0					2.3
Chemicals	1	1.5	0.5		120
Seed					
Mungbeans	30				18
Irrigated Maize		40			4.8
Rainfed Maize			40		4.8
Fuel	16	16	0	P/l	
Labor					
Seedbed	42	50	50	P/hr	7.5
Crop care	80	120	100		6.2
Harvesting	200	200	180		6.2
Threshing	35	0	0		7.0
Shelling	0	85	60		6.2
Drying	8	12	20		6.2
Capital					
Working capital	1,815	2,331	1,630	%	.14
Tractor	126	150	120	P/hr	6.5
Thresher	65			P/hr	12.5
Land	1	1	1		
Wet season (rainfed)				P/ha	1,500
Dry season (irrigated)					5,000
Mungbean (kg/ha)	750			P/kg	14
Maize (kg/ha)		2,500			4.6
Rainfed maize (kg/ha)			1,270		4.6

Screen 3.3: Multi-Commodity Budgets at Private Prices

	High Yield		Avg. Yield		Rainfed	Irrigated	Irrigated	Rainfed
	Wet	Dry	Wet	Dry	Paddy	Mung	Maize	Maize
Fertilizer:								
Urea	616	730	851	874	635	95	380	247
0-18-0	379	451	230	276	46	0	0	0
Chemicals	960	960	960	840	240	120	180	60
Seed	690	690	600	690	690	540	192	192
Fuel	429	1,715	643	2,144	0	107	107	
Labor:								
Seedbed	653	780	480	563	488	315	450	375
Crop care	1,550	1,488	942	1,085	620	496	744	620
Harvest	719	775	1,215	1,302	1,240	1,240	1,240	1,116
Threshing	84	98	56	77	35	245	0	0
Shelling	0	0	0	0	0	0	527	372
Drying	335	304	223	236	372	50	74	124
Capital								
Working	773	1,031	719	1,003	476	254	326	228
Tractor	910	1,170	1,560	1,690	910	819	975	780
Thresher	1,188	1,400	800	1,100	500	813	0	0
Land	3,500	7,100	2,380	5,000	1,500	5,000	5,000	1,500
Revenue	24,750	31,200	16,200	23,520	10,800	10,500	11,500	5,842
Costs	9,285	11,592	9,280	11,879	6,251	5,093	5,196	4,114
Profits	15,465	19,609	6,920	11,641	4,549	5,407	6,304	1,728
Net profit	11,965	12,509	4,540	6,641	3,049	407	1,304	228

CHAPTER 4: FARM BUDGETS AT SOCIAL PRICES

Information regarding private and social costs and returns allow the policy analyst to calculate:

(1) Private profits = returns to the willingness of an entrepreneur to manage resources and accept risk

(2) Social profits = returns to the economy when products and factors are valued at their opportunity costs

(3) Divergences = the effects of policy interventions and market failures, which are reflected in the difference between private and social costs, returns and profits.

This chapter takes an important step toward developing this information by adding a computation for social profits to the worksheet.

In order to simplify the initial calculations, Screen 4.1 provides social prices for tradables and nontradables. Monke and Pearson discuss the empirical estimation of social prices their Chapter 11. In preparation for the exercises in this manual the material in M-P's Chapter 6 ("Social Valuation of Commodities") and Chapter 7 ("Social Valuation of Factors") should be regarded as "required reading".

EXPANDING THE EXISTING WORKSHEET

The following major steps are required to calculate social profits in the existing worksheet:

(1) Retrieve the worksheet CHAPT3.WK1 created in the previous chapter.

(2) Copy the **P-Prices** table to the diagonal below and to the right of the private budget. Change the name of the new table to **S-Prices** and, using the ***Range Name Create*** command, add the new table to the list of named tables. Expand the column containing the table's labels so that they are all legible. The easiest way to do this is to use */WCS* and the **[Right Arrow]** key.

(3) Copy the P-Budget table to a position on the diagonal to the right and below the "S-Prices" table. Rename this table S-Budget and add it to the list of named tables. Expand the column containing the table's labels so that they are all legible.

(4) Add data to the social prices table by typing over the existing private prices. Use the *Copy* command to add data to all cells for which the numbers are the same.

(5) Change the formulas in the urea cost cell in the first column of the social budget table to reflect the appropriate addresses in the social prices table. Follow the method used in computing values in the private budget to copy the formulas into the entire data area including **Total Revenues**. (If you have forgotten how to do this, refer to p. 20.)

SOCIAL PROFITABILITY CALCULATIONS

The cost and revenue data for the social budget have already been calculated! Lotus 1-2-3 keeps track of relative cell addresses, so all of the cost and profit calculations are still valid and need not be changed. There is, however, one crucial distinction in the social budget table:

In the absence of clearly specified cropping alternatives, imputing opportunity costs to fixed factors within a single commodity budgeting framework is essentially arbitrary. Consequently, the land price, and thus cost, equals 0 and all returns to land are included in the Profits residual, i.e., Profits and Net Profits are the same. Social profits thus measure the returns to land and management when all commodities are priced at their efficiency prices. The rationale for this approach will be examined in greater detail in Chapter 5.

The results of the social profitability calculations are shown in Screens 4.1 and 4.2.

After the social budget table has been constructed, save the worksheet as CHAPT4.WK1. Save another backup copy.

Screen 4.1: Social Prices for All Commodities

	High Yield		Avg. Yield		Rainfed	Irrigated	Irrigated	Rainfed
	Wet	Dry	Wet	Dry	Paddy	Mung	Maize	Maize
Fertilizer:								
Urea	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
0-18-0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Chemicals	105	105	105	105	105	105	105	105
Seed	6.0	6.0	6.0	6.0	6.0	14.0	4.8	4.8
Fuel	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Labor:								
Seedbed	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Crop care	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Harvest	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Threshing	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Shelling	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Drying	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Capital								
Working	.14	.14	.14	.14	.14	.14	.14	.14
Tractor	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Thresher	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Output	4.0	4.5	4.0	4.5	4.0	11.0	4.0	4.0

Screen 4.2: Multi-Commodity Budgets at Social Prices

	High Yield		Avg. Yield		Rainfed	Irrigated	Irrigated	Rainfed
	Wet	Dry	Wet	Dry	Paddy	Mung	Maize	Maize
Fertilizer:								
Urea	778	922	1,075	1,104	802	120	480	312
0-18-0	545	647	330	396	66	0	0	0
Chemicals	840	840	840	735	210	105	158	53
Seed	690	690	600	690	690	420	192	192
Fuel	429	1,715	643	2,144	0	107	107	0
Labor:								
Seedbed	653	780	480	563	488	315	450	375
Crop care	1,550	1,488	942	1,085	620	496	744	620
Harvest	719	775	1,215	1,302	1,240	1,240	1,240	1,116
Threshing	84	98	56	77	35	245	0	0
Shelling	0	0	0	0	0	0	527	372
Drying	335	304	223	236	372	50	74	124
Capital								
Working	773	1,031	719	1,003	476	254	326	228
Tractor	910	1,170	1,560	1,690	910	819	975	780
Thresher	1,188	1,400	800	1,100	500	813	0	0
Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Revenue	22,000	29,250	14,400	22,050	9,600	8,250	10,000	5,080
Costs	9,492	11,860	9,484	12,124	6,408	4,983	5,273	4,172
Profits	12,508	17,391	4,916	9,926	3,192	3,267	4,727	908
Net profit	12,508	17,391	4,916	9,926	3,192	3,267	4,727	908

CHAPTER 5: THE POLICY ANALYSIS MATRIX

A BRIEF INTRODUCTION TO PAMS

The calculation of private profitability provides information on the competitiveness of commodity systems at actual market prices.[7] The same computations using social prices provide information on profitability when commodities and factors are priced at their social or opportunity costs. When the two are juxtaposed, the divergences--the differences between private and social valuations--provide insights into the extent of policy interventions in the form of taxes, subsidies, trade restrictions and exchange rate distortions. The comparisons also points to imperfections in the functioning of commodity and factor markets.

The **Policy Analysis Matrix (PAM)** reorganizes the data from the private and social budgets to facilitate the evaluation of policy effects and market failures on tradable inputs, domestic resources, and outputs.[8] The PAM format, shown in Figure 5.1 below, contains data on revenues, costs, and profits for an individual crop at private and social prices.

The policy analysis matrix is made up of two accounting identities; one defines profitability and the other measures policy effects and market failures, i.e., divergences.

Profits, shown by D and H in the right column, are calculated by subtracting all costs from revenues, in private and social terms for each respective row. The calculation of private profitability provides information on the competitiveness of commodity systems at actual market prices. The same computations using social prices provide information on profitability when commodities and factors are priced at their social or opportunity costs.

Policy effects and market failures, shown in the bottom row, constitute the difference between private and social values of outputs and inputs. These divergences provide insights into the extent of policy interventions in the form of taxes, subsidies, trade restrictions and exchange rate distortions. They also point to imperfections in the functioning of commodity and factor markets. The sum of the policy effects constitutes net transfers for a particular crop. Net transfers also indicate the difference between private and social profits for the commodity system.

Data collection represents the most difficult aspect of creating PAMs. The construction of I-O and price tables is far more challenging than the calculations of policy effects, market failures, and profits. For example, Monke and Pearson comment at length (p. 137-138) on the difficulty of classifying inputs and outputs due to wide variations in prices depending upon quality, timing, standardization, etc. The earlier sensitivity analysis indicated that budgets are very sensitive to output prices; therefore PAM results will be sensitive to output prices. The treatment of data sources for farm budget analysis contained in Chapter 6 in M-P should be read by everyone who

---

[7] In a perfectly competitive economy, there would be no private profits. Positive private profits indicate that some domestic factors are receiving rents.

[8] Chapter 2 of Monke and Pearson provides the authoritative introduction to the logic of the Policy Analysis Matrix.

Figure 5.1. The Policy Analysis Matrix

	Revenues	Costs		Profits
		Tradable Inputs	Domestic Factors	
Private prices	A	B	C	D
Social prices	E	F	G	H
Divergence	I	J	K	L

Private profits:	D = A - B - C
Social profits:	H = E - F - G
Output transfers:	I = A - E
Input transfers:	J = B - F
Factor transfers:	K = C - G
Net transfers:	L = D - H
	L = I - J - K

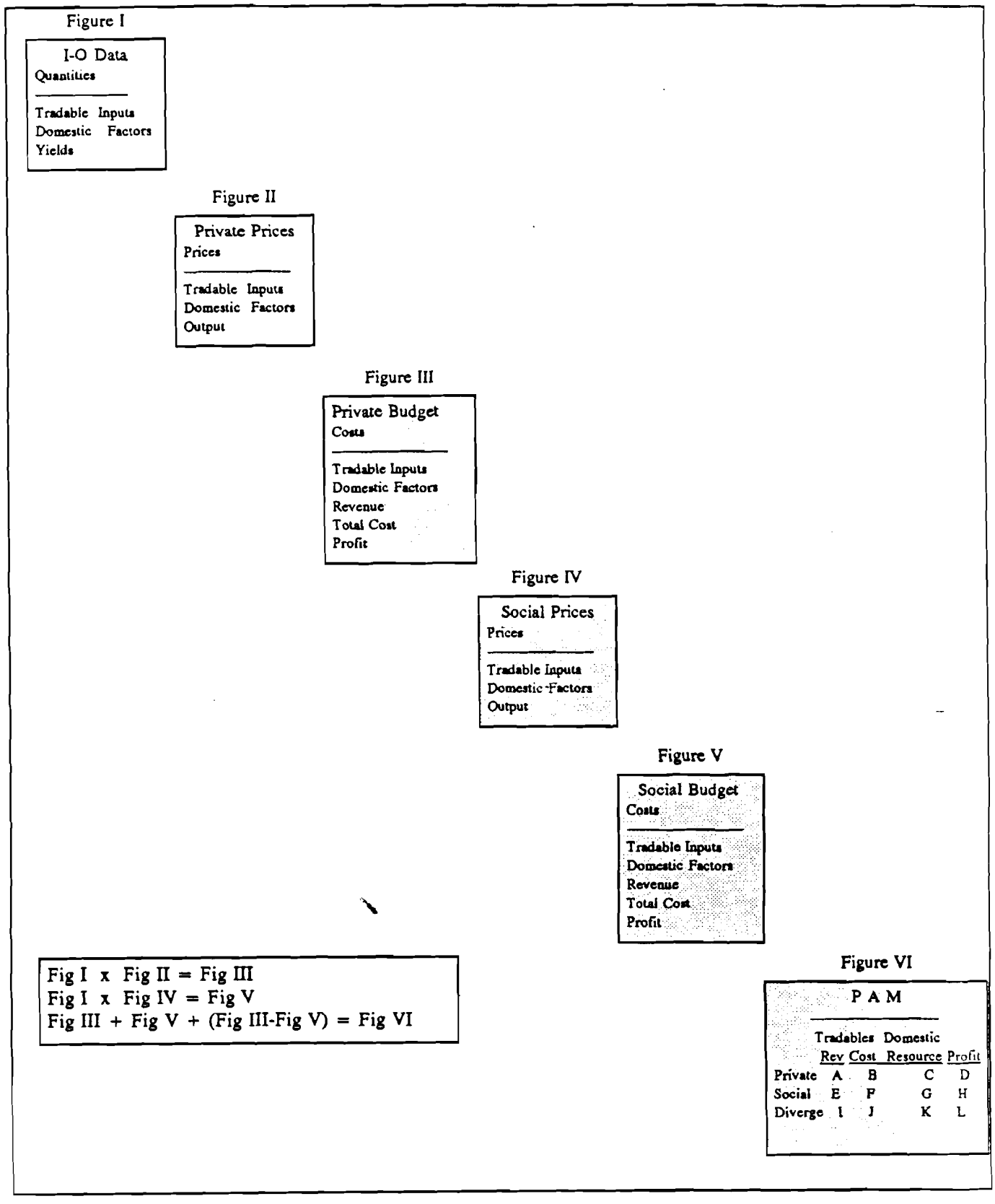
intends to construct their own PAM's.

Figure 5.2 illustrates schematically the relationship between the PAM approach and the diamondback method used in this manual. Once the tables have been arranged in this way and the appropriate linking formulas established, the same "template" can be used for other PAM problems. The labels and data can be changed by simply typing in the new entries. Additional columns and rows can be inserted and deleted without affecting the formulas in the tables.

The final PAM table is constructed from the private and social budget tables. The top or private profits row is obtained from Figure III, the private budget. The middle or social profits row is obtained from Figure V, the social budget. The last row, divergences, is obtained by subtracting numbers computed in Table V from Figure III.

Most of the work required to create PAMs for the Philippine food crops sector has already been done in previous exercises. The facilities of Lotus 1-2-3 make the final computations nothing more than the assignment of cell addresses.

Figure 5.2: Diamondback Display of PAM Calculations



CREATING A PAM FOR HIGH PRODUCTIVITY, WET SEASON PADDY

The first PAM exercise focuses on a single commodity PAM for which complete information on competing alternatives is not available. In such cases, private land costs can be obtained from the private rental market. But in the absence of information on the social profits of competing commodities, social returns to land are difficult to define. Consequently, in both the private and social computations, **Profits** in this PAM equal **Profits Excluding Land Costs**. Domestic resource costs include only labor and capital.

Retrieve CHAPT4.WK1 into the spreadsheet. Create a new table for the first PAM (high productivity, wet season paddy) on the diagonal to the right and below the S-Budget table. Use the table shown in Figure 5.3 as a guide. Label the table "Policy Analysis Matrix: High Yielding Wet Season Paddy" and give the table a name using the ***Range Name Create*** command. (For example, you might call this first PAM, "PAMHPP" for high productivity paddy.)

Figure 5.3. Single Commodity PAM

Policy Analysis Matrix
High Yielding, Wet Season Paddy

	Tradables		Domestic Resources		
	Output	Input	Labor	Capital	Profits
Private					
Social					
Divergences					

Additional PAMS for other commodities can be obtained by copying "PAMHPP" further down on the diagonal, changing the labels and editing the data cell addresses. **Note that only the column addresses change for each PAM.** The *row addresses* of the private and social budgets from which the PAM data are obtained remain the same. Consequently, it will save time to make the row addresses of the first PAM absolute addresses, for example, use K$55 instead of K55. When copied to the new PAM, the row address will remain the same regardless of where the PAM is located and only the column addresses will require adjustment.

Values for the "profits" column and the "divergences" row should be computed in the PAM and should not be transferred from the private and social budgets. This method allows for more straightforward movement from the original to subsequent PAMs. The necessary relative cell adjustments in the new PAM's will be made by the *COPY* command.

Entering Data Into the PAM

The necessary PAM cell entries that reference the private and social budgets can be obtained most easily with the judicious use of **Windows.**

Step 1

Create a horizontal, unsynchronized window that divides the screen in half, following the instructions introduced in Chapter 2. (Hint: use */WWH* followed by */WWU*).

Using the **[F5]** and **[F3]** functions, position the PAM table in the lower window and the appropriate budget table in the upper window. Use **[F6]** to jump back and forth between windows.

Step 2

Position the cursor in the appropriate PAM cell. Begin to create the necessary formula with a + for a single cell or @SUM(..) for a range such as the cost of tradable inputs.

Step 3

Use **[F6]** to jump back to the upper window and locate the cell address(es) that should enter the formula. When the appropriate cell has been highlighted, press **[Enter]**. Lotus will write the cell address of the budget into the PAM. (Note: in the case of the @SUM function, you will have to complete the process of identifying a range by typing in a closing parenthesis. Otherwise, Lotus will beep to let you know the formula is incomplete.) **Don't forget to make all rows in the cell addresses absolute!**

Step 4

Calculate the **Profits** cell by writing a formula that subtracts cells in the PAM containing tradable inputs and domestic costs from the PAM cell containing the value of output. Using the numbers in the PAM verifies the profit calculations in the budget and minimizes the use of absolute addresses.

Step 5

Complete the third row of the PAM by writing in the formula that subtracts the social value of output from the private value of output. Copy this formula into the other cells in the **Divergences** row.

The completed PAM for high productivity, wet season paddy is shown in Screen 5.1. The accuracy of most of the values in the table can be checked by direct comparison with the private and social budgets shown in Screens 3.3 and 4.2.

Interpret the results of the high productivity, wet season paddy PAM. What does it say about the extent of rice subsidies? What about input subsidies? (Chapter 12, pp. 226-236, of M-P provides detailed interpretations of a number of PAM's that can serve as models for interpreting the high

productivity paddy PAM.)

CREATING MUNGBEAN PAMS

A Single Commodity Mungbean PAM

Computing a single commodity soybean PAM, i.e., a PAM without full information about competing crops, can be accomplished quickly by copying the already completed paddy PAM further along the diagonal. **Remember to change the row addresses of the first PAM to absolute addresses if you did not enter them in this format.** Change the name and title of the PAM to indicate that it refers to the mungbean column of the private and social budgets. Name the PAM and add the name to the list of table names.

Use *Windows* or a piece of paper to edit the column names of the copied PAM to reflect the mungbean column in the private and social commodity budgets.

A Farming Systems PAM

The two previous PAMS were created under the assumption that the opportunity cost of land could not be identified. However, mungbeans is an irrigated crop which competes for the same land as average productivity dry season rice. Examination of both the **Profit** figures for rice clearly indicate that it is a superior alternative to mungbeans. This point can be demonstrated more dramatically by creating a mungbean PAM that includes a social cost for land in the form of the "**next best alternative.**" To compute such a PAM, first copy the original mungbean PAM to its appropriate place on the diagonal.

Then:

Step 1

Insert a column in the mungbean PAM to extend the domestic resource (non-tradable) category to include land. include land in the domestic resource category. */WIC*

Step 2

Use *Windows* to note the cell address for the cost of land for mungbeans in the private budget. Insert that cell address in the private cost cell for land in the new mungbean PAM. Go to the social budget and locate the cell that represents the highest value "**Profits Excluding Land Costs**" of the crops that compete directly for agricultural resources with mungbeans. In this case, the crop is average productivity dry season paddy. Insert the paddy cell address in the social profits row of the PAM under Land. **This value represents the opportunity cost of land to mungbean growers because it describes what the returns to land would have been had the land been used in the next best alternative.**

Examine the resulting farm systems mungbean PAM. Interpret the results from the perspective of private incentives. Is it possible for farmers to grow mungbeans? Where are the incentives for mungbean production coming from?

Is mungbean production socially profitable if **within** agriculture efficiency is considered, i.e., the opportunity cost of land is included as a domestic resource cost? What inferences can be drawn about the functioning of land markets on the basis of the evidence from the PAM?

ADDING A PAM FOR MAIZE

To create a maize PAM, repeat the steps used to develop the mungbean PAM.

(1) Copy the high yielding paddy PAM to a point on the diagonal below the mungbean system PAM.

(2) Edit the column portion of cell addresses of the private and social budget tables so that they refer to the maize column.

COMPUTING SUMMARY RATIOS

To compare the profitability and efficiency of different crops, a common numeraire must be used throughout the analysis. Ratios are one convenient method of avoiding the problem of a common numeraire, particularly when the production processes and outputs are very dissimilar. Several useful ratios that provide information on private and social profitability can be derived directly from the data in the policy analysis matrix. These ratios can then be used to rank crops according to different policy objectives. [9]

In this part of the exercise, the results from the previous PAMs will be used to calculate the **nominal protection coefficient**, the **effective protection coefficient**, and the **domestic resource cost coefficient**. The ratios will be calculated in a summary table so that the results can be compared easily between crops. The summary table is also convenient for conducting sensitivity analysis on the results.

Before calculating the ratios, create a new table for the summary table on the diagonal to the right and below the last PAM table. Use the **Range Name** command to call this table **Ratio**. The table consists of four rows, one for high productivity paddy, two for mungbeans, and one for maize. Three columns are shown, one for each of the three ratios. See Figure 5.4 for a suggested format.

Nominal Protection Coefficient (NPC)

The bottom row of the PAM indicates the extent of commodity and factor market distortions in the production of each crop. Without market failures, this row measures the effects of distorting policy on inputs and outputs. The nominal protection coefficient, defined by the ratio of private commodity prices and social commodity prices, compares the impact of government policy (or of

[9] For a more detailed discussion of various summary ratios including the DRC, see pp. 25-29 in Monke and Pearson.

Figure 5.4. Summary Ratios

Ratios of Efficiency and Protection

	Nominal Protection Coefficient		Effective Protection Coefficient	Domestic Resource Cost
	Output	Input		
High Yielding Paddy				
Mungbeans (alone)				
Mungbeans (rice as next best alternative)				

market failures that are not corrected by efficient policy) between different crops. [10]

The formula for the NPC on tradable outputs (i.e., crop output) is:

+ revenue in private prices / revenue in social prices

This ratio indicates the policy effect on the output. For example, an NPC greater than 1 shows that the market price of the output exceeds the social price. The farmer receives an output subsidy.

The formula for the NPC on tradable inputs is:

+ cost of tradable inputs in private prices / cost of tradable inputs in social prices

An NPC on tradable inputs of less than 1 indicates that market prices of inputs fall below the price that would result in the absence of policy. This ratio reveals the presence of input subsidies, taxes, trade restrictions raising or lowering prices or an inappropriate exchange rate.

Effective Protection Coefficient (EPC)

The effective protection coefficient, defined by the ratio of value added in private prices to value added in social prices, more completely measures incentives to farmers. The EPC indicates the combined effects of policies in the tradable commodities markets. This is a useful measure because

[10] "Efficient" policies are interventions deliberately introduced to off-set distortions caused by market failures. For a discussion of policies that promote food security in developing countries where imperfect capital and insurance markets make it difficult to obtain a desired protection against risk, see M-P, pp.53-54.

input and output policies, such as commodity price supports and fertilizer subsidies, often constitute part of a comprehensive policy package. For example, governments frequently reduce the price of outputs and then subsidize inputs in an effort to encourage the adoption of new technology.

The formula for the EPC is:

+ (revenue - cost of tradable inputs / (revenue - cost of tradable inputs
in private prices) in social prices)

An EPC greater than 1 indicates positive incentive effects of commodity policy (a subsidy to farmers) whereas an EPC less than 1 shows negative incentive effects (a tax on farmers).

Note: Both the EPC and the NPC ignore the effects of transfers in the factor market and therefore do not reflect the full extent of incentives to farmers.

Domestic Resource Cost Coefficient (DRC)

The domestic resource cost coefficient measures the efficiency, or comparative advantage, of crop production.

If the social returns to land cannot be identified clearly because full information about alternatives is lacking, the DRC may be calculated with respect to labor and capital only. It is calculated by dividing the cost of labor and capital by value-added at social prices.

The DRC will be positive unless the social value added in crop production is negative. However, DRCs greater than one indicate that the value of domestic resources used to produce the commodity exceeds its value added at social prices. Production of the commodity, therefore, does not represent an efficient use of the country's domestic resources. DRC's less than one imply that a country has a comparative advantage in producing the commodity. Values less than 1 mean that the denominator (net revenues of tradables measured at world prices) exceeds the numerator (the cost of the domestic resources measured at their shadow prices).

Where the opportunity cost of land can be clearly identified with another alternative, the DRC is calculated by including the cost of land in the form of the next best alternative. The resulting DRC reflects the country's comparative advantage, not only with respect to capital and labor, but within agriculture as well.

The formula for the single commodity DRCs is:

+ (labor cost + capital) / (revenue - costs of tradable inputs)

The formula for farming system PAMs in which the cost of land can be clearly identified is:

+ (labor cost + capital + land cost) / (revenue - costs of tradable inputs)

The costs and revenue must be in social prices and hence the source of the cell addresses is the social price row in the PAMs.

SENSITIVITY ANALYSIS

The stage has now been set to examine the sensitivity of the commodities for which PAM's have been computed to alternative assumptions about output, input and domestic factor prices. (Remember to create a horizontal, unsynchronized *window* to facilitate the interactive investigation of changes in the data tables.)

Examine the impact of the effects among crops if:

(a) Market fertilizer prices are raised to P5/kg

(b) The market price for mungbeans is lowered to P10/kg

(c) The market price for maize is doubled

(d) The yield for maize is doubled

(e) Social prices (reflected by changes in international markets) for paddy and mungbeans double.

Determine the "breakeven" world price that either gives or removes each crop's comparative advantage. If, by using a window, both the data table and the ratio table are in view on the screen, the breakeven price can easily be found by trial and error.

Screen 5.1: High Yielding, Wet Season Paddy PAM

Policy Analysis Matrix

High yielding, wet season paddy

	Tradables	Domestic Resources		
	Output	Inputs	Labor	Capital	Profits
Private	24,750	3,074	3,341	2,870	15,465
Social	22,000	3,281	3,341	2,670	12,508
Divergences	2,750	(207)	0	0	2,957

Screen 5.2: Irrigated Mungbean PAM

Policy Analysis Matrix

Mungbeans, irrigated

	Tradables	Domestic Resources		
	Output	Inputs	Labor	Capital	Profits
Private	10,500	862	2,346	1,886	5,407
Social	8,250	752	2,346	1,886	3,267
Divergences	2,250	110	0	0	2,140

Screen 5.3: Mungbean PAM (Including Land as a Cost)

Policy Analysis Matrix

Mungbeans, dry season paddy (farming system)

		Tradables	Domestic Resources			
	Output	Inputs	Labor	Capital	Land	Profits
Private	10,500	862	2,346	1,886	11,641	(6,234)
Social	8,250	752	2,346	1,886	9,926	(6,659)
Divergences	2,250	110	0	0	1,715	425

Screen 5.4: Summary Ratios

Ratios of Protection and Efficiency

	Nominal Protection Coefficient	Effective Protection Coefficient	Domestic Resource Cost
High Yielding Paddy	1.13	1.16	0.33
Mungbeans (alone)	1.27	1.29	0.56
Mungbeans (system)	1.27	1.29	1.89

CHAPTER 6: ESTIMATING SOCIAL PRICES

Previous chapters provided the social prices required to implement PAM computations as part of a prepared data set. This chapter shows how to calculate the import and export parity prices that measure social prices for tradable inputs and outputs. In most cases, analysts will be required to compute these prices as part of the PAM exercise.

Social prices are calculated on the basis of the opportunity cost ("most profitable alternative") of inputs and outputs. For tradable inputs and outputs, social prices are derived from prices in international markets. Estimation of social values for nontradable goods and domestic factors is more difficult and requires detailed knowledge of individual factor markets.

This chapter gives the details of computing social prices for only two commodities, paddy and maize. The purpose of the chapter is to provide an illustration of how import and export parity (equivalent) price calculations are made and to show how the results of these calculations should be linked by cell addresses into the social prices table. Like all elaborations of the PAM model, the tables for computing export and import parity prices are located along the diagonal and given names to facilitate quick access.

Important references for the computations made in this chapter are contained in Chapter 11 of the M-P text. Pages 188-199 deal with the calculation of domestic import and export parity prices when starting with the prices in international markets. That section also contains a discussion of the implications of over- or undervalued exchange rates for establishing the prices of tradables in domestic currency. Pages 199-209 address the difficult question of how to estimate social prices of factors, i.e., of domestic resources.

SOCIAL PRICES FOR TRADABLE GOODS

The social price of a tradable output (rice) or a tradable input (fertilizer) at the farm gate equals the international or border price adjusted for domestic transportation, processing and marketing costs. The resulting farm gate prices are called *import and export parity prices* or sometimes *border price equivalents*. They are computed in the following steps:

Step 1

The first step is to find an international price for the commodity. There are several ways in which this can be done. If the data are available, the simplest and most straightforward way is to consult the country's trade statistics. For imports, the appropriate measures are the so-called c.i.f. prices.[11] They can often be obtained by dividing the value of the imported commodity by the quantity imported. For exports, the appropriate value are f.o.b. prices and they can be computed in

[11] C.i.f. prices include the *cost* of the commodity in the exporting country plus the *insurance*, and *freight* required to move it from the point of export to the harbor of the importing country. Consequently, "border" prices have traditionally meant "at the border," and do not include the handling cost required to move goods from the boat to the dock of the importing country. The latter distinction is rendered meaningless in the case of truck, rail and air transport.

the same way.[12]

Using local sources may be misleading, however, when only limited amounts have been traded or trade has taken place under special concessional circumstances. In this case, the alternative to using country data is to use quotes from a major international market in which a large volume of the good is traded, and to make an adjustment for insurance and freight. Data on insurance and freight can be obtained from shipping companies or freight forwarders.

The computation of import parity prices using international market sources begins with the f.o.b. price at the border of the reference country, usually a major exporter. Insurance and freight are added to obtain the c.i.f. price in the importing country. Export parity prices can be obtained in a similar fashion. In this case, however, the reference is the border of major importers. Insurance and freight are subtracted to arrive at f.o.b. prices at the local border.

Step 2

The second step in computing parity prices is to find an appropriate **exchange rate** at which to convert prices expressed in international currency to prices expressed in domestic currency. The official exchange rate can be used in the calculations only if it accurately reflects the true scarcity value of foreign exchange. In many developing countries, the official foreign exchange rate is overvalued and its availability is rationed through a system of exchange controls. Hence it must be adjusted to reflect the true "willingness of the economy to pay" for tradable goods and services.

When the **equilibrium foreign exchange rate (EER)**--the social price that reflects the true value of foreign exchange--differs from the official exchange rate, the difference can be expressed as a **foreign exchange premium.** For example, if the official exchange rate is overvalued by 10 percent, then the shadow exchange rate equals the official rate times (1 + .1).[13]

Once an EER is selected, international prices can be converted to local currency by multiplying the international price times the equilibrium exchange rate.

Step 3

The third step in computing the value of a commodity at the farm gate requires costing the marketing, transportation, storage and processing activities that link the border to the farm. The computation can be broken into two parts. For imports, the first part consists of *adding* the costs of activities between the border and the wholesale market where the farmer sells or purchases the commodity; imports cost more as they move from the border inland. For exports, the reverse is true. Marketing, transportation and processing costs between the wholesale market and the border

---

[12] F.o.b. (free on board) prices are measured on the boat in the harbor of the exporting country.

[13] The discussion on the top of page 197 in M-P regarding the need to adjust for exchange rate overvaluation is misleading. Their suggestion that no such adjustments are required because factor markets will eventually adjust is a long run view that is inconsistent with the short and medium run analysis on which the PAM approach is based. A more complete discussion of equilibrium exchange rate computation when partial equilibrium methods are being used is contained in Isabelle Tsakok, *Agricultural Price Policy*, Cornell University Press, 1991.

are *subtracted*; exports are worth less at the wholesale market than they are at the border.

The second part of the computation involves the link between the wholesale market and the farm gate. In the case of imports, the calculation depends upon whether the commodity is an output or an input. For outputs, the c.i.f. plus value of the commodity at the wholesale market is too high because it does not take into account the cost to the farmer of bringing his goods to market. Hence the farm to wholesale distribution costs must be subtracted. For inputs, the opposite is true. Inputs must be transported to the farm to be used and hence distribution costs must be added to the wholesale price to obtain a farm gate price.

For exports, farmers must incur the cost of taking the commodity to market thereby reducing the value of the commodity at the farm gate relative to its price in the wholesale market.

Because post-farm goods and services are non-traded, the costs of transportation, marketing and processing are locally determined. It might be assumed therefore that, except in the case of underemployed facilities, private prices and social prices were the same. However, even in the absence of direct government trade policies or market imperfections, private costs may not equal social costs. Transportation and processing facilities in particular may have a high import content in the form of equipment, fuel, parts, etc. If the country is attempting to maintain an overvalued exchange rate, these imports have cost less than they would have had an equilibrium exchange rate prevailed. Theoretically therefore, the cost of non-traded goods and services must be decomposed into their traded input and non-traded domestic factor components. Chapter 8 illustrates the decomposition computations for non-traded goods that the theory requires. However, in this chapter, it is assumed that the private costs of non-traded goods and services such as transportation and marketing provides an estimate of their social costs. The more complete calculations will subsequently be linked by cell addresses to the data initially provided without explanation.[14]

DETERMINING IMPORT PARITY PRICES

The following steps are used in the calculation of import parity prices for farm outputs:

Steps for Calculating Import Parity Prices for Farm Output

Start	f.o.b. price at point of export
Add	freight to point of import
Add	insurance

[14] In Chapter 8, "Constructing PAM's for Commodity Systems," Monke and Pearson point out that focusing the PAM analysis entirely on the farming system may be quite misleading. When assessing the competitiveness and efficiency of a commodity system, it may be equally or even more important to investigate the policy interventions and market imperfections associated with transportation, processing and marketing. If there are significant divergences between private and social profits in these elements of the commodity system, then estimates for private and social profits at the farm gate will be biased.

Equals c.i.f. at point of import

Convert world price in foreign currency to border price in domestic currency at EER

Add local transport and marketing costs to wholesale market, valued in social prices

Equals social value at wholesale market

Apply the processing conversion factor which adjusts the social value of the imported commodity for any processing it requires

Equals import parity value at regional market before processing

Deduct transport, marketing, and storage costs to farm, valued at social prices

Equals import parity value at farm gate

For a farm input, i.e., fertilizer, the costs of distribution (i.e., transport, marketing costs) from the wholesale or regional market to the farm should be added instead of subtracted from the import parity value at the wholesale or regional market, to arrive at the equivalent import parity value for the input at the farm gate level. The same commodity could be treated differently, depending upon its origin. For example, distribution costs of maize grown on the farm and sold in the wholesale market would be subtracted. However, the distribution costs between the farm gate and the wholesale market of maize purchased for livestock feed would be added to obtain its import parity price.

Calculating the Import Parity Price for Paddy in Nueva Ecija

Follow the steps shown above to calculate the import parity price (social price) of paddy at a major regional wholesale center for rice like Nueva Ecija in the Philippines. Begin by creating a new table in the existing worksheet along the diagonal called "Import". Remember to copy the existing worksheet under a new name (e.g.,"Chapt6") before adding the new tables. The new table (Import) will consist of two columns: one for the labels and one for the calculations. Expand the label column to 30 characters using the */WCS* command.

Table 6.1 shows a sample format for the table. Use the following assumptions in the computations:

(1) f.o.b. Bangkok price of rice (35% brokens) equals $260/ton

(2) insurance and freight costs from Bangkok to Manila equal $15.57/ton.

(3) official exchange rate $1 = P22

(4) foreign exchange premium = 20%

(5) conversion from tons to kg: 1000 kg = 1 ton

(6) transportation costs from port to wholesale market equal P0.50/kg

(7) marketing costs from port to wholesale market equal P0.35/kg

(8) processing conversion factor from paddy to rice: 1 kg. paddy = .64 kg. rice

(9) wholesale to farm distribution margin = P0.51/kg

Assume for the purposes of this table that there are no distortions in the transportation and marketing sectors so that private and social prices are equal.

All of the calculations involve simple arithmetic as shown in the steps above. However, pay attention to three important **conversions** required for transforming the international price ($/ton) into a comparable domestic market price (Pesos/kg).

Conversion 1: Converting international prices in $ to local currency (Pesos).

Conversion 2: Converting tons, the usual international price unit, to kilograms.

Conversion 3: Converting a finished products (e.g., rice) to its raw (paddy) equivalent

DETERMINING EXPORT PARITY PRICES

The export parity price is the border price of an exportable good adjusted for transport and marketing costs and revalued by the EER. The calculations for the export parity price resemble those for the import parity price, but generally work in the opposite direction. The following steps are used in the calculations:

Steps for Calculating Export Parity Prices

Start	c.i.f. price at point of import
Deduct	freight to point of export
Deduct	insurance
Equals	f.o.b at point of export
Convert	world price in foreign currency to border price in domestic currency at EER
Deduct	local transport and marketing costs to wholesale market, valued in social prices
Equals	social value at wholesale market
Apply	the processing conversion factor which adjusts the social value of the exported commodity for any processing

Equals export parity value at regional market

Deduct farm to wholesale distribution costs

Equals export parity value at farm gate

Calculating the Export Parity Price for Maize in Mindoro

Follow the steps above to calculate the social price of maize in Mindoro, assuming that maize is an exportable good. (Note: Philippines occasionally exports maize and at other times imports maize.) Create the table for the export parity price along the diagonal in the existing worksheet. Remember to assign a range name to the table with the **Range Name Create** command. Call the new table "Export".

As in the import parity table, the export parity table consists of a column of labels and a column of data and calculations. The labels can be copied directly from the import parity table using the **Copy** command. Use the edit command [F2] to change "add" to "deduct" in the new table. Table 6.2 illustrates the export parity calculations.

Use the following assumptions in the calculations:

(1) c.i.f. Taiwan price for no. 2 yellow maize equals $216/ton

(2) costs of insurance and freight between Taiwan and Manila equal $14.86/ton

(3) official exchange rate: $1 = P22

(4) foreign exchange premium = 20%

(5) transportation costs from port of Manila to Mindoro wholesale market equal P0.60/kg.

(6) marketing costs from port to wholesale market equal P0.25/kg.

(7) conversion of weights: 1000 kg = 1 ton

(8) farm to wholesale distribution costs: P0.42/kg

A conversion factor is not necessary for the processing of maize, a commodity sold on international markets in an unprocessed form.

LINKING TABLES IN THE WORKSHEET

Link the results of the import and export parity calculations directly into the social price table using **cell addresses**. Make a note of the cell addresses for the import parity price of rice and the export parity price of maize. Move to the social price table using the **[F5]** and **[F3]** keys and type the appropriate cell addresses into the rows for rice and maize. Remember to begin the formula with a +. For rice, type an **absolute cell address** (e.g., +$A$1) and copy the formula to the

remaining rice columns. A single address also can be used for maize grown in high productivity and rainfed areas.

The worksheet is now fully integrated so that sensitivity analysis on international prices and

Table 6.1: Import Parity Calculations

	Rice
F.O.B. Bangkok, 35% brokens ($/ton)	260
Add	
Freight and insurance ($/ton)	15.57
Equals	
C.I.F. price in the Philippines ($/ton)	275.57
Exchange rate (P/$)	22
Exchange rate premium	0.20
Equilibrium exchange rate (P/$)	26.40
C.I.F. in domestic currency (P/ton)	7275
Weight conversion (kg/ton)	1000
C.I.F. price (P/kg)	7.28
Add	
Transportation (P/kg)	0.50
Marketing (P/kg)	0.35
Equals	
Value before conversion (Rp/kg) (processing)	8.13
Processing conversion factor	0.64
Equals	
Import parity value at wholesale (P/kg)	5.20
Total distribution costs to farm (P/kg)	0.51
Equals	
Import parity value at farm gate (P/kg)	4.69

exchange rates can be reflected in the social budgets. Use the Windows command to keep the social budget in view. How does the social profitability for the paddy and maize systems change when:

(1) the exchange rate premium equals 30%

(2) the international price of rice rises to $320/ton

(3) the international price of maize falls to $150/ton

The Import and Export Parity Price Tables assume an exchange rate premium of 20 percent, which means that the exchange rate is overvalued by 20 percent. Although many developing countries experience overvalued exchange rates, it is often difficult to ascertain the exact amount of the premium. Hence it is desirable to test the results of different ERR assumptions. However, as Chapter 10 indicates, making changes in the exchange rate premium to test the influence of different assumptions regarding the equilibrium exchange rates is <u>not</u> the same as simulating exchange rate policy. The latter has its affect on private and not social prices.

SUMMARY

This chapter demonstrated the necessary steps for calculating the social prices of tradable commodities. Although the computations are simple and straightforward, data requirements are often formidable. For example, in identifying the f.o.b. and c.i.f. prices in international markets, it is usually difficult to ensure equivalence in specifications (e.g., quality) between the traded product the domestically available product. Even small comparability mistakes can swamp large errors in input-output coefficients.

Table 6.2: Export Parity Calculations

	Maize
C.I.F. price, Taiwan, No.2 yellow maize ($/ton)	216
Deduct	
Freight and insurance	14.86
Equals	
F.O.B. price at Philippine port ($/ton)	201.14
Exchange rate (P/$)	22
Exchange rate premium	0.20
EER	26.40
F.O.B. in domestic currency (P/ton)	5310
Weight conversion (kg/ton)	1000
F.O.B. price (P/kg)	5.31
Deduct	
Transportation (P/kg)	0.60
Marketing (P/kg)	0.25
Equals	
Value before conversion (processing) (P/kg)	4.46
Processing conversion factor	1
Equals	
Export parity value at wholesale (P/kg)	4.46
Distribution costs from farm to wholesale (P/kg)	0.42
Equals	
Export parity value at farm gate (P/kg)	4.04

CHAPTER 7: COMPUTING ADDITIONAL PARITY PRICES

Chapter 7 expands the import parity table to include mungbeans and most tradable inputs in the budget. Upon expanding the structure of the tables, parity prices for each commodity can be computed. For the most part, these import parity prices will link into the social price table using **relative cell addresses.** (The exceptions are prices that are computed in the export parity price table.)

Calculations for import and export parity prices in this chapter follow directly from the previous chapter.

IMPORT PARITY PRICES

Begin by copying the file from the previous chapter ("Chapt6") into a new file called "Chapt7." Retrieve this file onto the screen.

Move to the import parity table using the [**F5**] and [**F3**] keys. Insert 10 columns to the right of "Rice" by typing /**WIC** and highlighting the appropriate area. Import parity prices for mungbeans, urea, 0-18-0, Chemicals, seeds (for paddy, mungbean, and maize), and fuel (gasoline) will be calculated in the additional columns.[15]

Type headings for these commodities as shown in Table 7.1.

Use the assumptions shown in this table to compute import parity prices for the additional commodities.

EXPORT PARITY PRICES

Move to the export parity table and insert 2 columns to the right of "Maize" for Maizeseed and Urea. Urea is used domestically in agricultural production, but is also exported to other countries in the region. Use the same price assumptions for freight, insurance, and marketing as used for 0-18-0 in the previous section. The numbers in the transportation row are again provisional.

The C.I.F. prices in the importing countries (i.e., Philippines's export markets) for the additional commodities are:

(1)	Maizeseed:	$240/ton
(2)	Urea:	$159/ton

[15] While corn is an export commodity, corn seed is neither exported nor imported in this example. This is because its export parity price is lower than its private price while its import parity price is higher than its private price. Its import parity value and export parity value at the farm level are both calculated and shown to demonstrate this case. In such circumstances, the private price becomes equivalent to its social price.

Table 7.1: Data for Computing Import Parity at Social Prices

Import Parity Prices	Output			Inputs					
	Paddy (wet)	Paddy (dry)	Mung	0-18-0	Chemical	PaddySeed	Mungseed	Maizeseed	Fuel
F.O.B. prices ($/ton)	260	265	396	70	3750	165	440	225	182
Freight and Insurance	15.57	15.57	22.56	6.89	162.88	10.00	25.91	14.88	10.42
C.I.F. (Philippines)	275.57	300.57	418.56	76.89	3912.88	175.00	465.91	239.86	192.42
Exchange rate (P/$)	22	22	22	22	22	22	22	22	22
Exchange rate premium	.20	.20	.2	.20	.20	.20	.20	.20	.20
Equilibrium rate	26.40	26.40	26.40	26.40	26.40	26.40	26.40	26.40	26.40
C.I.F. (local currency)	7,275	7,935	11,049	2,030	103,300	4,620	12,300	6,332	5,079
Conversion (kg/t)	1000	1000	1000	1000	1000	1000	1000	1000	1000
C.I.F. price (P/kg)	7.28	7.94	11.05	2.03	103.30	4.62	12.30	6.33	5.08
Transport	.50	.50	.50	.50	.50	.50	.50	.50	.50
Marketing	.35	.35	.69	.34	.80	.38	.70	.35	.82
Processed value (P/kg)	8.13	8.79	12.24	2.87	104.80	5.50	13.50	7.16	6.40
Processing conversion	.64	.64	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Import parity (wholesale)	5.20	5.62	12.24	12.87	104.60	5.50	13.50	7.18	6.40
Distribution (farm)	.51	.51	.49	.36	.54	.50	.50	.42	.50
Import parity (farm gate)	4.69	5.11	11.75	3.23	105.14	6.00	14.00	7.60	6.90

Table 6.2: Export Parity Calculations

	Maize	MaizeSeed	Urea
C.I.F. price, Taiwan, No.2 yellow maize ($/ton)	216	240	159
Deduct			
Freight and insurance	14.86	14.86	6.89
Equals			
F.O.B. price at Philippine port ($/ton)	201.14	201.14	152.11
Exchange rate (P/$)	22	22	22
Exchange rate premium	0.20	0.20	0.20
EER	26.40	26.40	26.40
F.O.B. in domestic currency (P/ton)	5310	5944	4016
Weight conversion (kg/ton)	1000	1000	1000
F.O.B. price (P/kg)	5.94	5.31	4.02
Deduct			
Transportation (P/kg)	0.60	0.60	0.50
Marketing (P/kg)	0.25	0.25	0.34
Equals			
Value before conversion (processing) (P/kg)	4.46	5.09	3.18
Processing conversion factor	1	1	1
Equals			
Export parity value at wholesale (P/kg)	4.46	5.09	3.18
Distribution costs from farm to wholesale (P/kg)	0.42	0.42	0.36
Equals			
Export parity value at farm gate (P/kg)	4.04	4.67	2.82

Copy the formulas for the export parity calculations from the "Maize" column to the additional columns after entering the appropriate data. An illustration of the expanded export parity price table is shown in Table 7.2.

NON-TRADED GOOD PRICES

In this exercise, the seed for maize is assumed to be non-traded, though it has international prices. The reason for this is made clear by comparing its computed import and export parity prices (Tables 7.1 and 7.2) at the farm gate level. Transport and marketing costs differentials account for the spread between the P7.60 import parity price and the P4.67 export parity price. Hence, even under a free trade policy regime, this commodity will not be traded if its domestic production cost falls in-between this price spread. For maize seed, the private price of P4.80/kg (below the import but above the export parity prices) reflects a willingness to pay and hence reflects both its private and social prices.

CHAPTER 8: ANALYSIS OF NONTRADABLE SERVICES

Previous chapters have ignored the issue of nontradable services such as machine rentals, transportation, processing, and marketing. Collecting data for these nontradable services is one of the most challenging, and often frustrating, exercises in agricultural policy analysis. Because the information is difficult to collect and, once gathered, may only have a marginal impact on the results, analysts frequently resort to broad assumptions about the data, using sensitivity analysis to verify that these assumptions would not do violence to their conclusions.

But as Monke and Pearson point out in their Chapter 10 ("Postfarm Budgets and Analysis"), market imperfections or policy divergences in nontradable goods and services should not be treated in a cavalier fashion. Chapter 8 in this manual focuses on policy divergences in the tradable component of tractor services and illustrates how these divergences affect private and social budgets. In theory, the costs of all nontradable inputs (goods and services) should be decomposed into their tradable inputs and domestic factor cost components. These costs, standardized on units such hours or measures of volume or weight, can then be substituted into the appropriate cells of the private and social prices tables.

DECOMPOSING TRACTOR COSTS

In Chapter 1, the labor associated with tractor and thresher services (i.e., tractor driver and thresher operator) were included as labor in various cultural operations and labor in threshing. The rent of capital associated with these services was included in the capital account. Rental services, however, may contain a significant tradable component in the form of machine depreciation, fuel, and grease and oil. Of course, they also include labor in the form of organization administration and capital in the form of working capital and investment costs.

This exercise decomposes tractor services and assigns tradables, labor and capital to their respective accounts in the budgets. Assume that the tradable component of the tractor service budget consists of the depreciation of the tractor itself, fuel, and grease and oil. The nontradable component consists of the use of labor for maintenance and administration of the tractor rental operations, and capital to pay for operational expenses (working capital).

Table 8.1 contains the input-output table and prices (private and social) for the tractor decomposition. The unit of standardization is the tractor service hour. Tradable prices will be multiplied times hours of tractor use given in the commodity input-output table. Adjustments will also have to be made in the labor and capital sections of the table to account for the use of domestic factors in running the tractor rental service.

Create the new table along the diagonal to the right and below the export parity price table. Assign the table a name ("Tractor") with the **Range Name** command.

The costs of tradable tractor services are constructed along the same lines as the commodity import parity prices. F.O.B. prices obtained from exporting countries are the point of departure if local estimates of the C.I.F. prices in foreign currency are unavailable. The likelihood that the latter can be found is substantially greater that would be the case for commodities since local importers will know what their landed costs are.

Table 8.1: Data for Tractor Budget

I-O	Units per tractor service hour					
Tradables						
Service (hours/hr)	1					
Fuel (liters/hr)	0.135					
Grease and Oil (liters/hr)	0.0052					
Non-Tradables						
R&M Labor (man-hr/hr)	0.015					
Working capital	5.20					

PRICES	Private			Social		
	Tractor	Fuel	Grease	Tractor	Fuel	Grease
F.O.B. ($/unit)	5,000.00	0.50	3.40	5,000.00	0.50	3.40
Freight and insurance	400.00	0.15	0.15	400.00	0.15	0.15
C.I.F.	5,400.00	0.65	3.55	5,400.00	0.65	3.55
Official exchange rate	22	22	22	22	22	22
Exchange rate premium	0	0	0	0	0	0
Equilibirum exchange rate	22	22	22	22	22	22
C.I.F. (Domestic)	118,800	14.30	78.10	142,560	17.16	93.72
Domestic duties (%)	0.4	0.4	0.3	0	0	0
Domestic subsidies	0.0	0.0	0.0	0	0	0
Domestic cost	166,320	20.02	101.53	142,560	17.16	93.72
Tractor life (hours)	25,000			25,000		
Cost per hour	6.65			5.70		
Transportation	.10	1.00	3.00	.10	1.0	3.00
Farm gate cost per unit	6.75	21.02	104.53	5.80	18.16	96.72

PRICE PER SERVICE HOUR	Private	Social
Tradables		
Tractor depreciation (P/hr)	6.75	5.80
Fuel (P/hr)	2.84	2.45
Grease and oil (P/hr)	0.54	0.50
Total cost per hour of tradables	10.13	8.76

The results of the calculations give total costs per hour of tractor services in private and social prices. The difference between private and social costs in tractor services originate from the same sources as the divergences in the agricultural sector. For example, in the tradable category, many governments subsidize tractor services by permitting tractor dealers to import tractors and spare parts and pay for them with hard currency obtained at an overvalued exchange rate. Gasoline and diesel fuel are also frequently subsidized. Interestingly, in the Philippines imports of machines are heavily taxed in order to encourage and protect the domestic production especially of smaller machineries like two-wheeled tractors. Imports of oil is also significantly taxed instead of

subsidized, though the degree of taxation is somewhat offset by granting foreign exchange allocations at a cost below the equilibrium exchange rate for imports of machinery and production inputs. The off-setting effects of an overvalued currency and import duties can be seen from the private and social price calculations in Table 8.1.

LINKING TABLES IN THE WORKSHEET

The most time consuming part of this exercise is linking the results back to earlier calculations. Several steps are involved.

Step 1: (Modifiying the tradables section)

(a) Add a new row in the tradables section of the (1) the I-O table, (2) the prices tables, and (3) the budget tables. (The partial I-O table shown in Screen 8.2 indicates where the entries should be inserted to insure that they will be included in the formulas used to compute the PAMs.)

(b) Copy the hours from the "Tractor services" row currently in the Capital section to the newly created tradables row in the I-O table. These coefficients describe the number of tractors hours used by each commodity. They will be multiplied times the cost per hour computed in Table 8.1 to obtained the total cost of tradable tractor services.

(c) Insert the cell address of the hourly cost of tradable tractor services computed in Table 8.1 into the first cell of the tractor services row in the Private Prices table. Make this an absolute cell address (**F4**) and copy it into all cells in the tractor services row. Do the same for the hourly social cost of tractor services.

(d) In the tradables section of the Private and Social Prices budgets, copy the formula that multiplies quantities times prices from the row above the newly inserted tractor services row. This should compute the total cost of the tradable component of tractor services for each budget.

Step 2: (Modifying the labor section)

(a) Add a new row in the labor section of the (1) the I-O table, (2) the prices tables, and (3) the budget tables. (The partial I-O table shown in Screen 8.2 indicates how the entries should be inserted to insure that they will be included in the formulas used to compute the PAMs.)

(b) To obtain the coefficients in the tractor service row of the labor section in the I-O table, multiply the hours in the "Tractor services" row currently in the tradables section by the coefficient of the Tractor Service decomposition table labeled: "R&M labor". The coefficient in the decomposition table describes the amount of repair, maintenance, and administrative labor used by the vendor to deliver one hour of tractor services. Make the decomposition table address an absolute address and copy into all columns in the tractor services row.

(c) In the Private and Social Prices tables, copy the wages from the preceding row into the newly created tractor services row.

(d) In the labor section of the Private and Social Prices budgets, copy the formula that

multiplies quantity (I-O table) times prices (Prices table) from the row above the newly inserted tractor services row. This should compute the total cost of the labor component of tractor services.

Step 3: (Modifying the capital section)

(a) Add a new row in the capital section of the (1) the I-O table, (2) the prices tables, and (3) the budget tables. (The partial I-O table shown in Screen 8.2 indicates how the entries should be inserted to insure that they will be included in the formulas used to compute the PAMs.)

(b) To obtain the coefficients in the tractor service row of the capital section in the I-O table, multiply the hours in the "Tractor services" row currently in the tradables section by the coefficient of the Tractor Service decomposition table labeled: "Working capital". The coefficient in the decomposition table describes the amount of working capital used by the vendor to deliver one hour of tractor services. Make the decomposition table address an absolute address and copy into all columns in the tractor services row.

(c) In the Private and Social Prices tables, copy the season interest rate from the preceding row into the newly created tractor services row.

(d) In the capital section of the Private and Social Prices budgets, copy the formula that multiplies quantity (I-O table) times prices (Prices table) from the row above the newly inserted tractor services row. This should compute the total cost of the capital component of tractor services.

As noted above, integrating the results of the decomposition into the existing tables is the most time consuming part of the exercise. However, such integration is highly desirable because it simplifies the sensitivity analysis of various types of policy proposals. For example, once the template has been properly implemented, it will be easy to see if significant changes in the international price of tractors has an impact on commodity PAMs.

Adjusting the PAMs

If the PAMs have been done correctly in the earlier exercises, changes in the Tractor Decomposition table should be automatically reflected in the PAMs. In order to gain a better understanding of the relative importance of nontradable service decomposition, perform the following sensitivity analysis. As usual, space is provided for comments.

1) Tractor prices increase by 100%

2) Fuel prices triple

Do the PAM results change much? What do the results of this sensitivity analysis suggest in terms of data collection priorities?

SUMMARY

This chapter has shown how to decompose nontradable services into their tradable and nontradable components. The illustration was simplified for ease of presentation, but the difficulty in computing costs of nontradable services should not be underestimated. Due to the inherent problems of estimating the social costs of services, it is often useful to assess their importance in the budget of individual commodities before embarking on a complete analysis. This can be done by computing the value of nontradable services as a share of total costs and by performing sensitivity analyses. The diamondback method makes it possible to incorporate a more comprehensive analysis at a later date if the nontradable services are thought to play an important role.

CHAPTER 9: INCLUDING CAPITAL RECOVERY COSTS

Chapter 9 includes the opportunity costs of fixed capital in the PAM analysis. Including such costs is somewhat awkward in a budgeting framework where the focus is on annual variable costs and not on fixed costs. However, over the usual lifetime of policies being analyzed, farmers make decisions about investment items whose costs are fixed annually. Failure to include annualized fixed input costs in some form would lead to distortions, not only in decisions about durable capital goods, but also the selection of crops and technologies.

As Monke and Pearson note in the text (pp. 139-141), one simplified but incomplete way to deal with the problem of finding the annual cost of a fixed input would be to divide its initial cost by the life of the input. This same method can be used to apportion the annual cost between different commodities, i.e., each crop could be debited in proportion to the time the fixed inputs were used in its cultivation. However, this approach ignores the opportunity cost of the capital tied up in the fixed input. The farmer could have put the money in the bank rather than investing it in a fixed production asset. Therefore, the fixed input charge against a particular crop should include both the appropriate portion of the total cost and the interest on the embodied capital.

ADJUSTING THE I-O TABLE

The first step in including a capital recovery cost is to account for the use of fixed inputs in the Input-Output table. This requires inserting a row for each item to be included. In the interest of simplicity, this example only accounts for capital recovery for the irrigation pump. In practice, the farmer may own other implements which may need to be fully accounted for in the budgeting process.

Go to the I-O table in a copy of the CHAPT8.wk1 spreadsheet. *Insert* a row just above the Thresher Capital row. Enter data given in Table 9.1 on the number of pump hours per hectare used by each crop.

Table 9.1: Pump Hours/Hectare

	Rice Systems					Irrigated		Rainfed
	High Productivity		Avrg Productivity		Rainfed	Mung	Maize	Maize
	Wet	Dry	Wet	Dry	Wet	Dry	Dry	Wet
Pump (hp-hr)	640	2560	960	3200		160	160	

THE CAPITAL RECOVERY COST TABLE

The second task is to develop an intermediate table for calculating the annual capital recovery cost per hour of use. The table to be entered on the diagonal in the worksheet is shown in Screen

9.1. The contents of the various cells are also given below.

Screen 9.1: Capital Recovery Cost Table

Capital Recovery Cost (Pesos per hp-hr)	Private Prices	Social Prices
	Water Pump	Water Pump
Initial cost (P/15 hp-unit)	15000	9000
Useful life (years)	10	10
Salvage value (P)	1500	900
Interest rate (%/year)	28%	28%
PV salvage	127.05	76.23
Net cost	14872.95	8923.77
Recovery ratio	0.31	0.31
Annual recovery	4549.81	2740.25
Total hp-hours	7200	7200
Recovery/hp-hour (P/hp-hr)	0.632	0.381

(1) The initial cost and useful life of the machine represent the two most important parameters of the capital cost recovery calculations. After its useful life has expired, the machine may still have a salvage value as scrap and a source of parts and this value should be included as part of the computation.

(2) Fill in the interest rate cell by writing a formula which references the interest rate in the first column of the Private Prices interest rate. Follow the same procedure for the Social Prices table. These steps integrate the spreadsheet so that subsequent sensitivity analysis on the interest rate will require the alteration of only one parameter, i.e., the number corresponding to the interest rate row in the first column of the relevant Prices table.

(3) The salvage value is received 10 years in the future, therefore the present value of the salvage value must be computed. The formula for calculating the value of the cell is shown below where i = the interest rate and n = the number of time periods (in this case, years of useful life).

$$\frac{SALVAGE\ VALUE}{(1+i)^n}$$

Cell address of salvage value/ (1 + cell for interest rate) ^ cell address for useful life

where ^ is the arithmetic operator for exponentiation.

(4) Net cost is initial cost minus PV of salvage.

(5) Monke and Pearson derive the formula used to compute the capital recovery cost factor on p. 140 of their text. It is defined "as the annual payment sufficient to repay the cost of the fixed input at the end of its useful life." The formula used to compute the capital recovery cost rate is:

$$\frac{(1+i)^n i}{(1+i)^n - 1}$$

The spreadsheet implementation of the formula is shown below.

*((1 + i) ^ useful life * i)/ (((1 + i)^ useful life) -1)*

(6) Annual recovery cost is the recovery factor computed in (5) times the net cost figure reported in (4).

(6) Total hours is annual machine *capacity* in hours. [16]

(7) Recovery per hour is the annual recovery costs (6) divided by total hours (7). It will be multiplied by the hours shown in the input-output table.

Screen 9.2 shows the initial private and social prices of the machine. In many developing countries manufactured equipment is often wholly or partially imported. It must then be treated like any other input. The tradable components must be valued at international prices which are in turn converted to domestic prices using the equilibrium exchange rate. The nontradable factors used in its domestic manufacture or assembly must be valued at their shadow prices using the methods described in Chapter 8.

ADJUSTING THE PRIVATE AND SOCIAL BUDGETS

Step 1:

Use **[F5]** and **[F3]** to go to the Range Names menu. Select P-Prices and go to the private

[16] Using the *capacity* of the machine as the denominator seems preferable to the practice of computing percentage of use on the basis of total hours actually used. The latter depends upon the choice of a cropping pattern and thus is a function of the entire cropping system. By using capacity, the denominator becomes exogenous. The assumption that there is no surplus machine capacity in the sector also seems more consistent with the long run concerns of the PAM analysis than using total actual hours.

prices budget table. Add a line for water pump under the capital section in the same way that it was added in the input-output table. In the first (leftmost) pump cell, enter the **absolute address** of the recovery rate per hour shown at the bottom of the pump column in Screen 9.2.

Step 2: Make the same change in the Private Budgets table, i.e., insert a row above the thresher row. Copy the cell addresses that multiply the I-O table times the prices table from the line above. (Copying the formula into the cells of non-irrigated crops will not hurt; the result will simply be zero.)

Step 3: Repeat the procedure for the social prices table and the social prices budget. The cell address in the capital recovery table should be the social prices capital recovery factor.

ADJUSTING THE PAMS

If the preceding steps have been done correctly, the ranges in the @SUM command should have been expanded and there should be no further steps necessary for the effect of the capital recovery calculations to take effect on the PAMs.

CHAPTER 10: SENSITIVITY TO MACROECONOMIC ASSUMPTIONS

Macroeconomic disequilibria, such as overvalued exchange rates, can swamp commodity policies that attempt to provide positive incentives to production. Policy makers often want to see the results of sensitivity analysis regarding such macro variables as interest rates, exchange rates, and wage rates. This chapter explains how to construct import and export parity prices for *private prices,* integrate macroeconomic assumptions table into the spreadsheet, and evaluate the impact of overvalued exchange rates on the PAMs.

PRIVATE PRICES AND POLICY ANALYSIS

In order to simulate the impact of specific policies on private prices, it is necessary to decompose *observed* private prices into "parity prices" similar to those calculated for social prices in Chapters 6 and 7. These private "parity prices," are based on (a) international prices, (b) official exchange rates, and (c) taxes and subsidies that reflect the effects of agricultural policy. In the absence of quantity restrictions, they should approximate prices observed in the market place.

Steps:

(1) Copy the Social Import Parity Table created earlier to the next place on the diagonal and call it the Private Import Parity Prices table.

(2) Use the Range/Names/Create command to add this table to the list of named tables. Call if PIMPORT.

(3) Change the Exchange Rate Premium label to Percent Devaluation. Change the EER label to Post Devaluation Rate.

(4) Insert four lines under CIF Price (P/kg) and label them:

Percent Net Trade Tax
Percent Domestic Subsidy
Percent Domestic Tax
Domestic (P/kg)

(5) Enter exogenously the net trade, domestic subsidy and tax *rates* shown in Screen 10.1. (These numbers may subsequently be replaced with the cell addresses of foreign trade taxes, and local subsidies and taxes drawn from assumptions table if commodity policies (i.e., trade protection policy, domestic taxation policy) are to be analyzed.)

Table 10.1: Data for Computing Import Parity at Private Prices

Import Parity Prices	Outputs			Inputs					
	Paddy (wet)	Paddy (dry)	Mung	0-18-0	Chemical	PaddySeed	Mungseed	Maizeseed	Fuel
F.O.B. prices ($/ton)	260	265	396	70	3750	165	440	225	182
Freight and Insurance	15.57	15.57	22.56	6.89	162.88	10.00	25.91	14.88	10.42
C.I.F. (Philippines)	275.57	300.57	418.56	76.89	3912.88	175.00	465.91	239.86	192.42
Exchange rate (P/$)	22	22	22	22	22	22	22	22	22
Devaluation (%)	.00	.00	.00	.00	.00	.00	.00	.00	.00
Post devalutation rate	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
C.I.F. (local currency)	6,062.54	6,612.54	9,208.32	1,691.58	86,083.36	3,850.00	10,250.02	5,276.92	4,233.24
Conversion (kg/t)	1000	1000	1000	1000	1000	1000	1000	1000	1000
C.I.F. price (P/kg)	6.06	6.61	9.21	1.69	86.08	3.85	10.25	5.28	4.23
Net trade taxes (%)	.15	.15	.45		.38	.20	.60		.15
Domestic subsidies (%)	0	0	0	.35	0	0	0	.35	0
Domestic taxes (%)	0	.02	0	0	0	0	0	0	.10
Domestic price (P/kg)	6.97	7.47	13.35	1.10	118.80	4.62	16.40	3.43	5.29
Transport	.50	.50	.50	.50	.50	.50	.50	.50	.50
Marketing	.35	.35	.69	.34	.80	.38	.70	.35	.35
Processed value (P/kg)	7.82	8.32	14.54	1.94	120.10	5.50	17.25	4.28	6.14
Processing conversion	.64	.64	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Import parity (wholesale)	5.01	5.33	14.54	1.94	120.10	5.50	17.25	4.28	6.14
Distribution (farm)	.51	.51	.49	.36	.54	.51	.51	.51	.51
Import parity (farm gate)	4.50	4.82	14.05	2.30	120.64	6.01	17.76	4.79	6.65

(6) Call the fourth row Domestic Price (P/kg) and calculate by multiplying the CIF price (P/kg) by (1 + (net trade tax + local subsidy - local tax)). (Note in developing the cell formulas that net trade taxes are positive, subsidies are positive, and local taxes are negative for the case of import-competing outputs. In the case of imported inputs, the local subsidy and local tax signs are reversed. For example, local taxes must be *added* to the CIF price as they increase the price of the imported input.) In order to account for the possibility that several programs may affect the same commodity, write the formula so that the effective policy rate is the difference between the subsidy rate and the tax rate.

4 The formula for the domestic price of output is: **C.I.F. Price * (1 + (net trade tax + subsidy rate - tax rate))**. For inputs, the signs on the subsidy rate and the local tax rate are reversed.

(8) Add the transportation and marketing costs to get the Private Import Parity Price at the farm gate.

The Private Export Parity Prices table is constructed in the same way. The domestic price is calculated by adding subsidies and deducting taxes, i.e.local and foreign trade taxes, the cell formula is: **F.O.B. Price * (1 + (subsidy rate - local tax rate - net trade tax rate))**. The objective is to choose a combination of trade taxes and domestic price policies that will reproduce the private prices for export commodities such as maize, maize seed and urea. Remember, as in the case of the original social parity prices table, transportation and marketing costs are *deducted* rather than added.

LINKING TABLES IN THE WORKSHEET

Using the **/WWH** and **/WWU** commands, create a window with the Private Import Parity Prices table in one window and the original Private Prices table in the other. Begin with the inputs. In the first commodity column for 0-18-0, reference the Private Import Parity Price for 0-18-0, then press **[F4]** to make the cell address absolute. Next, copy the formula into the remaining commodity columns. Repeat this procedure for 0-18-0 and the other fertilizers and chemicals. For seeds, repeat the same steps, but be sure to copy the rice seed price formula **only** into the rice columns. In the rest of the commodity columns, reference the appropriate seed price.

For output prices, move to the last row of the Private Prices table, Output (P/kg). Reference the Private Import Parity Price for rice in the first rice column, make the formula absolute, and copy it to the remaining rice columns. Use the same procedure to reference the Private Import Parity Price of mungbeans in the Private Prices table.

Repeat the entire procedure for the Private Export Parity Price table.

CREATING AND INTEGRATING THE ASSUMPTIONS TABLE

The assumptions can be either very elaborate or very simple depending on the extent of the desired sensitivity analysis. Table 10.2 suggests only a few obvious candidates for such a table:

(1) The *nominal interest rate*. The nominal interest rate is the return to capital in private markets. Markets for capital are often highly distorted in developing countries. Sensitivity analysis of the private interest rate helps determine whether special agricultural credit programs have a significant impact on the sector's competitiveness.

(2) The *social interest rate*. The social interest rate reflects the long-run opportunity cost of capital. A very difficult indicator to measure, the World Bank and other international agencies estimate social interest rates and periodically publish their results.

(3) The *official exchange rate*. The government sets this rate and uses it for government transactions. This policy parameter enters in the translation of international output and input prices into domestic currency.

(4) The *exchange premium* measures the extent to which the official exchange rate is over or undervalued. (See Monke and Pearson, pp. 197-198, 261.)

(5) The *devaluation percent*. Changing this figure simulates a devaluation policy.

Once the measures in the macroeconomic assumptions table have been developed, they need to be linked to the private and social budgets created earlier. For example:

(1) Link the nominal interest rate to the private prices table. The link to the capital recovery table has already been made and the changes to the capital recovery factor and subsequently to the private budgets will be made automatically.

(2) Link the social return to capital to the social prices table. As in the private budget case, the link from the prices table to the capital recovery factor and to the social budget will be automatic.

(3) Link the exchange rate and the exchange rate premium to the export and import parity price calculations. **Do not** link the official exchange rate to these tables, because social prices should not move with devaluation. Sensitivity analysis can be performed on the exchange rate premium to test the responsiveness of PAMs to alternative assumptions about the equilibrium exchange rate.

(4) Link the official exchange rate and the devaluation percent to the new **private** import and export parity price tables. This connection will make it possible to simulate changes in exchange rate policy.

(5) (Optional) Create new rows in the assumptions table for taxes and subsidies on commodities and/or inputs. Link these tax and subsidy entries into the appropriate cells in the private import and export parity tables.

ASSESSING THE IMPACT OF A DEVALUATION ON MAIZE

Now that the spreadsheet is fully integrated, a number of sensitivity analyses on macroeconomic

Screen 10.2: Assumptions Table

```
    Assumptions Table
-------------------------------------
    Nominal interest rate      28%
    Social interest rate       28%
    Official exchange rate     22
    Exchange Premium           20%
    Percent Devaluation         0%
    Rice Tariff                 5%
    Mungbean Tariff            80%
    Maize Export Tax            5%
```

indicators can be performed. This section illustrates the effect of devaluation on the maize PAM.

First, create a window and put the assumptions table on one side and the maize PAM on the other. Assume the government has decided to devalue the currency by 20 percent in order to eliminate the degree of overvaluation assumed to exist. Change the official exchange rate from 22 to 26.40 in the assumptions table. Try and answer the following questions:

(1) What is the overall effect of the devaluation on the results of the PAM?

(2) Is the percentage change in the level of divergences between private and social prices exactly equal to the 20 percent devaluation? Why and why not?

(3) How can the farming system register an apparent "subsidy" overall when the output appears to remain "taxed?"

(4) Why does devaluation only affect the price of tradables and not the price of factors? Can factor prices be expected to increase with adjustment to the new devaluation?

(5) What implications for policy analysis can be drawn from the devaluation experiment?

Repeat the devaluation experiment for other commodities. Try to answer Questions 1-5 using other PAMs.

FINAL COMMENTS REGARDING THE DIAMONDBACK METHOD

At this point there are more than a dozen tables along the diagonal of the worksheet. The early tables are arranged according to a series of tasks. For example, the I-O table is first, then comes the private prices table, then comes the private budget table. The placement of subsequent table entries, however, is the result of adding complexity to the PAM analysis in the form of a more complete analysis of nontradable inputs and fixed inputs. If the /Range Name Create command has been used conscientiously to name each table, their precise location on the spreadsheet makes little difference. Use of the **[F3]** and **[F5]** keys, along with the **Windows** command, provides a means of moving about the spreadsheet quickly and efficiently.

After becoming more familiar with the PAM approach and the diamondback method, users may wish to rearrange sequence of the tables. For example, private and social prices could be entered side-by-side under different headings in the same table, thereby minimizing the need for table copying. The same might be done for private and social budgets. Indeed, experienced users may wish to complete the international price tables and the capital recovery cost table before the private and social prices tables since the former tables feed into the latter. But these are all matters of taste for the individual researcher. So long as the diamondback approach is preserved and tables are identified with Range Names, the flexibility to proceed in any order will be maintained. The spreadsheet software, using a "natural" order of recalculation, will decide which cells should be computed prior to other cells and the order in which the formulas are entered will have little discernable effect on the speed with which the final results are computed.

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

Under contract to U.S.A.I.D., Bureau of Science and Technology, Office of Agriculture
Project Office: Hampden Square, 4800 Montgomery Lane, Suite 500, Bethesda, MD 20814
Telephone: (301) 913-0500 • Telex: 312636 • Fax: (301) 652-3839 • Fax: (301) 652-7791

AGRICULTURAL AND NATURAL RESOURCES POLICY ANALYSIS COURSE

Market Level Analysis
Multi-Market Models

Methods and Guidelines No. 401

Volume 2

Prepared for: Agricultural Policy Analysis Project, Phase II (APAP II)
A.I.D. Contract No. DAN-4084-Z-00-8043-00

Authors: Leigh Bivings
Carl Gotsch

Prime contractor: Abt Associates, Inc., 55 Wheeler Street, Cambridge, MA 02138 • (617) 492-7100

Subcontractors:

Harvard Institute for International Development, Harvard University, One Eliot Street, Cambridge, MA 02138 • (617) 495-2164
Food Research Institute, Stanford University, Stanford, CA 94305-6084 • (415) 723-3941
North Carolina State University, Department of Economics and Business, Box 7645, Raleigh, NC 27695-7645 • (919) 737-7187
Abel, Daft & Earley, 1410 King Street, Alexandria, VA 22314 • (703) 739-9090
International Science and Technology Institute, 1129 20th Street, NW, Suite 800, Washington, D.C. 20036 •(202) 785-0831
International Food Policy Research Institute, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036 • (202) 862-5600

TABLE OF CONTENTS

PREFACE 3

CHAPTER 1: THEORETICAL BACKGROUND OF MARKET ANALYSES 1
THE COMMODITY SUPPLY CURVE 1
THE COMMODITY DEMAND CURVE 5
LIMITATIONS OF SURPLUS MEASURES 9
ANALYZING MARKET INTERVENTIONS 10
PAMS vs. MARKET LEVEL ANALYSIS 13

CHAPTER 2: ANALYSIS OF A SINGLE COMMODITY POLICY 15
ORGANIZING MARKET LEVEL MODELS ON A SPREADSHEET 15
ORGANIZING THE WORKSHEET 17
A PRODUCER TAX 19
A CONSUMER SUBSIDY 24
COMBINED PRODUCER-CONSUMER INTERVENTIONS 25
TARIFF POLICY 26
SENSITIVITY ANALYSIS 27

CHAPTER 3: INTRODUCTION TO MULTI-MARKET MODELING 33
THE CONCEPT OF MULTI-MARKET EFFECTS 33
CALCULATING MULTI-MARKET EFFECTS 35
A PRODUCER TAX 36

CHAPTER 4: MULTI-MARKET MODELS WITH PRICE ENDOGENEITY 40
ILLUSTRATING A FEEDBACK EFFECT 40
MATHEMATICAL REPRESENTATION OF A MULTI-MARKET MODEL 42
SOLVING SIMULTANEOUS EQUATIONS BY MATRIX INVERSION 44
SOLVING THE MULTI-MARKET PROBLEM 45
ANALYZING THE RESULTS 49
GENERATING MULTIPLE SOLUTIONS 50
LOTUS MACROS AND SENSITIVITY ANALYSIS 52

CHAPTER 5: EXTENDING THE MULTI-MARKET MODEL 54
QUANTITATIVE RESTRICTIONS 54
ENLARGING THE TWO-COMMODITY MODEL 57
ADDITIONAL REGIONS 61
COMBINING THE EXTENSIONS (ADVANCED) 68

PREFACE

The simpliest approach to agricultural policy analysis for individual commodities relies on farm level budgets. This technique is particularly helpful in examining the effects of interventions in markets for outputs and inputs that are traded in international markets. It also leads to the identification of imperfections in factor markets where these imperfections can be detected by divergences between the market price of domestic resources and their opportunity cost.

Budgeting methods focus on the supply side of policy interventions and prices are taken to be exogeneous. In the initial exercises in this volume, the focus is also on situations in which prices are determined exogenously, either by government policy or by international markets. However, the market level analysis takes the policy discussion further in at least two ways: (1) the demand side is taken into account, and (2) adjustments to price changes are permitted on the supply side. This is accomplished, in the first instance, using the traditional supply and demand curves of neo-classical analysis in a single commodity world. Subsequently, price exogeneous methods are extended to more than one market under the assumption that significant cross-price effects exist. In the final chapters, the assumption that prices are exogeneous is relaxed to include markets in which the prices of non-traded commodities are determined by the interaction of domestic supply and demand.

Chapter 1 reviews the theoretical background of the neo-classical market model giving particular attention to the concepts of elasticities and producer/consumer surplus. As in the case of single commodity budgeting models, much that is of importance in understanding the impact and incidence of agricultural policy becomes apparent using some very simple tools. In Chapter 2, Philippine rice policy serves as a vehicle for doing spreadsheet calculations that move policy analysis from the theoretical to the practical.

Chapter 3 extends the single commodity analysis and examines agricultural policy in a multi-market framework. Initially, the focus remains on exogenous policy or trade determined prices. However, the multi-market framework makes it possible to develop a more complete picture of the indirect effects of policy reform.

Models in which prices are exogenous give way in Chapter 4 to a simple model containing a nontradable commodity whose price is determined entirely in domestic markets. This requires more advanced computational methods and matrix inversion techniques are used to find the values of the simultaneous equations that are generated by the problem. A final chapter extends the multi-market analysis further by incorporating additional commodities, differential taxes and subsidies, and by showing how multi-market models can examine regional comparative advantage.

The limitations of these types of models are well known. Although the data requirements are relatively modest, finding estimates of supply and demand elasticities can be particularly difficult. This is especially true of the cross-elasticities that are the basis of the interactions between commodities in a multi-commodity, i.e., multi-market framework. Moreover, the models depend upon point elasticities and hence are technically valid only in the immediate vicinity of the estimate. Policy reforms often involve drastic changes, however, and hence any set of elasticities needs to be treated with caution. Fortunately, the ease with which sensitivity analysis can be carried out permits

the effects of alternative elasticity estimates to be explored in detail.

Numerous individuals have served as "beta testers" for these exercises; their efforts to reduce the number of "bugs" have been much appreciated. Particular thanks are due to Timothy Josling, not only for his role as a tester, but for his willingness to share his enormous experience in implementing multi-market models on spreadsheets

Thanks are also due to the Agricultural Policy Analysis Project (APAP), funded by the U.S. Agency for International Development, for providing the resources to prepare this manual. Futher information about this project, its newsletter and its published material in the agricultural policy field, can be obtained from Abt Associates, Inc., Hamden Square, 4800 Montgomery Lane, Suite 600, Bethesda, MD 20814.

Carl H. Gotsch
July, 1991

CHAPTER 1: THEORETICAL BACKGROUND OF MARKET ANALYSES

Chapter 1 reviews the most important concepts employed in the traditional supply-demand market equilibrium model. Limited space and the many available textbook treatments of the topic dictate that the exposition be brief. However, the chapter provides a refresher for participants who have had previous training in economics and is a a ready reference for the spreadsheet exercises that follow.

The chapter is divided into four sections. The first reviews the derivation of the supply curve from the marginal cost curves of the firms in an industry. Because the concept of the price elasticity of supply figures so prominently in the market level analysis, it is also reviewed in some detail. Lastly, the notes on supply response discuss the derivation and significance of producer surplus for policy analysis.

The second section treats the demand curve in an analogous manner. First, the neo-classical derivation of the demand curve from an aggregation of consumer preferences is discussed. Then the concept of demand elasticities is reviewed. The last part of the section deals with the notion of the consumer surplus and its implications for policy analysis.

The third section brings together the supply and demand curves for an illustration of market level policy analysis. Some discussion is devoted to the difference between the modeling of tradable and nontradable commodities. In the former case, prices are assumed to be exogenous to the determination of a market equilibrium when the country's share of the world market is small. Adjustments to price changes result in changes in the net import variable. Subsequently, nontradables whose prices are domestically determined, are introduced into the discussion. [1]

The final section in Chapter 1 relates the market level analysis to the concepts of the policy analysis matrix presented (PAM) in Volume II and provides a brief comparison between the two approaches.

THE COMMODITY SUPPLY CURVE

The Firm's Supply Curve

In Figure 1.1, the SMC_1 curve represents the individual firm's short-run marginal cost curve. Underlying the shape and position of the curve are considerations such as the state of technical knowledge, the prices of commodities closely related to commodity X in production, and the supply curves of the factors of production employed in producing commodity X. Given the prices of the factors, there will be some optimum combination of factors for producing any given output, and some minimum marginal cost of producing that output. If, for any given output, that marginal cost

[1] The analysis of the large country case whose tradable commodity prices are also endogenous is not treated in this volume.

is less than the output price but greater than the average cost of producing that output, the firm has an incentive to expand. Accordingly, the portion of the marginal cost curve above the minimum point on the firm's average total cost curve, ATC_1, for a given set of factor prices, will be the firm's short-run supply curve for X. The portion of the marginal cost curve below the minimum point of the firm's ATC_1 curve does not establish supply points, because the firm's profit will be negative for any price less than minimum average costs.

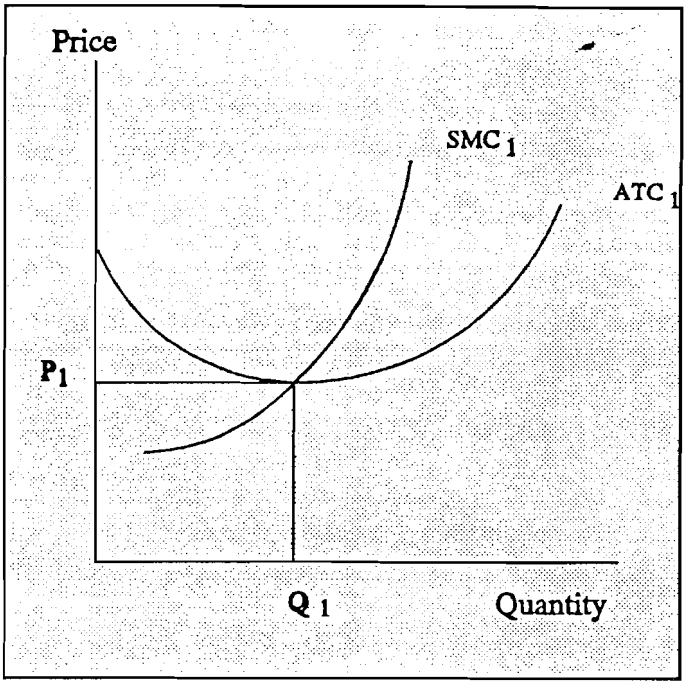


Figure 1.1: The Firm's Short Run Supply Curve

The Industry's Supply Curve

It has been shown that the firm's short-run supply curve is the portion of its short-run marginal cost curve above its minimum ATC curve. The industry short-run supply curve might be thought of as the horizontal sum of such firm supply curves, S, shown in Fig. 1.2. However, in a competitive industry, in response to a price increase to P_2, all firms will try to expand along their SMC_1 curves. The combined expansion of all firms may increase the prices of the variable factors of production. If so, each firm's average and marginal cost curves will shift upward to SMC_2 and ATC_2, and each firm will expand output to Q_2, less than the amount Q_3 suggested by the original marginal cost curve.

These smaller increases in each firm's output sum to a smaller amount of output at the industry level. Thus the actual supply curve of the industry, S^*, is the horizontal summation of firms' SMC curves corrected for factor price changes as industry output expands or contracts. Factor price effects normally operate to reduce the magnitude of the supply response to changes in output prices, that is, they steepen the industry supply curve.

The Elasticity of Supply

Attention has already been directed to the role of factor markets in determining the position and shape of the commodity supply curve. These relationships are made explicit in farm and sector level optimization models where the decision about modeling factor markets such as land and labor is an important determinant of the model's response to prices. Market equilibrium methods, however, while acknowledging the underlying determinants of supply response, use an empirically derived estimate that implicitly incorporates these influences. In this type of analysis, the value that

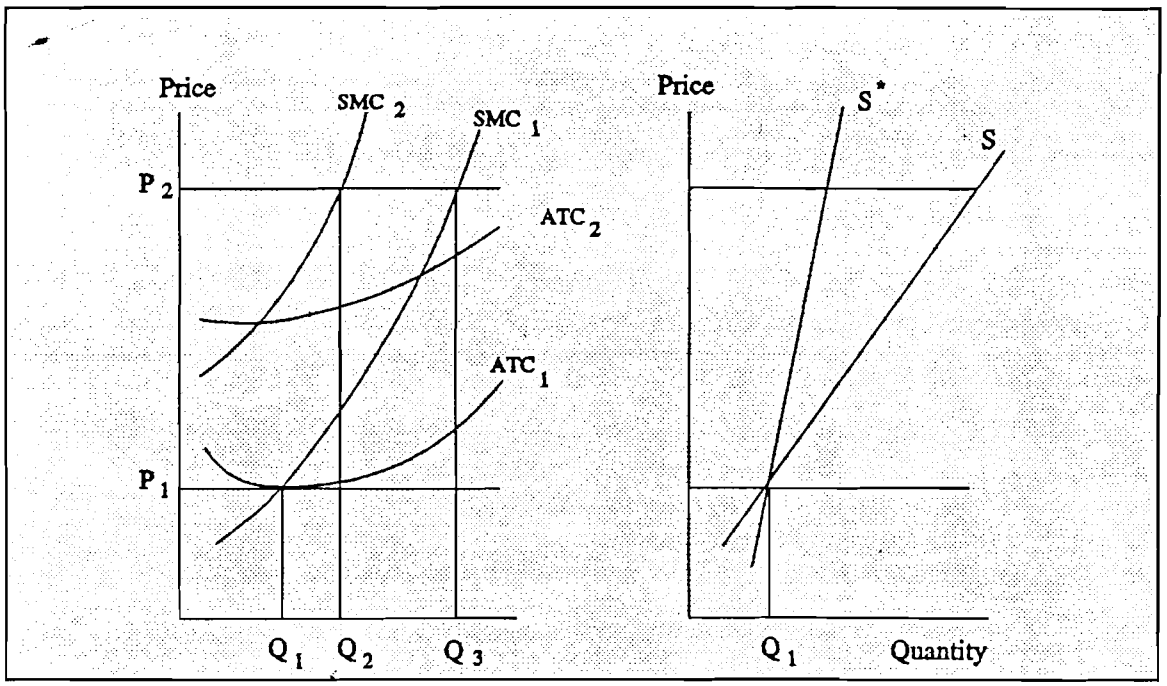


Figure 1.2: The Short Run Industry Supply Curve

captures the *total* change in supply in response to a change in the output price is known as the *total price elasticity of supply.*

The total price elasticity of supply, denoted by the upper case Greek letter *epsilon*, is defined as:

$$E_s = \frac{\textit{corresponding relative change in quantity supplied}}{\textit{relative change in output price}} \qquad (1.1)$$

where all factor and other relevant commodity prices are allowed to adjust to the output price change. In symbols,

$$E_S = \frac{(\Delta S/S)}{(\Delta P/P)} = \frac{\Delta S}{\Delta P} \cdot \frac{P}{S} = \frac{\%\Delta S}{\%\Delta P} \qquad (1.2)$$

where S = supply, ΔS = change in supply, P = price, and ΔP = change in price.

Price elasticities of supply are statistically estimated parameters which relate a proportional change in price to a proportional change in quantity. For example, suppose the elasticity of supply for rice in Indonesia is 0.2. This elasticity indicates than for every 10% change in the price of rice,

the quantity produced will change by 2%. The changes in quantity and price are normally defined as infinitesimal changes although in practice they may be substantial. P and S are the price and quantity at the point at which the elasticity is measured. In calculations, these are often referred to as *initial* or *base year* P's and S's. (It is important to keep in mind that the definition refers to percentage changes in prices and quantities. By making the changes percentage changes, i.e., by introducing the initial or base year P and S into the definition, elasticities are independent of the units in which quantities and prices are quoted.)

A virtual industry has grown up around the estimation of supply response elasticities. The results of several decades of work in developing countries on supply response in agriculture is summarized in Askari and Cummings (1976).[2] The results have been further summarized in Timmer, Falcon and Pearson (1983) and Isabelle Tsakok (1990).[3]

The definition of the elasticity given above applies to a point on the supply curve. A similar expression can be derived that makes it possible to compute an elasticity in the absence of continuous curves and statistically estimated mathematical functions. This is done by defining an *arc elasticity* as being the elasticity mid-way between two sets of price-quantity observations, P_0, S_0 and P_1 and S_1. In the absence of sufficient data for econometric estimation--such rough and ready methods may be required.

$$E_S = \frac{(S_0 - S_1) / (S_0 + S_1)}{(P_0 - P_1) / (P_0 + P_1)} = \frac{S_0 - S_1}{S_0 + S_1} \cdot \frac{P_0 + P_1}{P_0 - P_1} \qquad (1.3)$$

Producer Surplus

The notion of producer surplus follows from the analysis of supply presented earlier. Figure 1.1 showed how each point on the supply curve represents the marginal cost of producing that unit of output. Summing firm specific curves (Figure 1.2) gives the industry supply curve or the industry marginal cost curve. Under the assumption that the area under the curve is made up entirely of variable costs, this amount represents a payment to factors purchased in the market. Since all producers receive the same price in the market, firms other than the marginal firm (one whose revenue is exactly equal to its costs), will be receiving a rent over and above the returns needed to cover the payments to variable factors. The sum of the rent received by all inframarginal firms is called the *producer surplus* shown by the shaded area A in Figure 1.3. In other words, the

---

[2] Hossein Askari and John T. Cummings, *Agricultural Supply Response: A Survey of Econometric Evidence*, New York, Praeger, 1976.

[3] For a survey of the results by commodity, see p. 108 of Timmer, Falcon and Pearson, *Food Policy Analysis*, Johns Hopkins University Press, Baltimore, MD, 1983. (The entire chapter on "Understanding Farming Systems" is highly recommended.) An even more comprehensive review of empirical estimates can be found in Isabelle Tsakok, *Agricultural Price Policy: A Guide to Partial Equilibrium Analysis*, Cornell University Press, 1990.

producer surplus is the return to fixed factors such as land and/or management. If the price rises to P_2, production will increase from Q_1 to Q_2 and the rent earned by the inframarginal firms will increase by the striped area B in Fig 1.3. Because the supply curve is based on payments to factors, producer surplus is a net concept that takes the additional costs of responding to the increase in the commodity price into account.

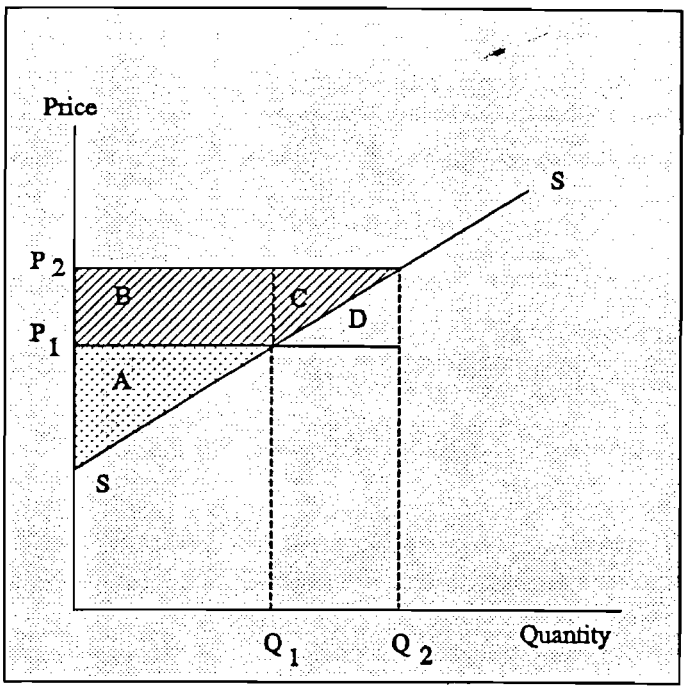


Figure 1.3: Producer Surplus

The concept of producer surplus is only one component of measuring the welfare implications of policy changes. Although producers benefit from the increase in the price of commodity X, consumers of the commodity suffer. Their consumer surplus declines. In general, policies that claim to improve overall welfare must benefit one group more than they hurt another.

Surplus concepts measure the change in welfare in moving from one allocation of resources to another. As explained above, the concept of producer surplus indicates the change in income (profits) accruing to owners of factors of production resulting from changes in policy or market conditions. As will be seen, the concept of consumer surplus indicates the changes in *real* income accruing to consumers also resulting from changes in policy or market conditions.

THE COMMODITY DEMAND CURVE

A demand curve for a particular commodity can be defined as a locus of points, each of which shows the maximum quantity of the commodity that will be purchased at a particular price. It is often useful to conceive of a demand curve as a boundary line separating two spaces, the space to the left of the demand curve representing the points that are attainable under the given conditions of demand, in the sense that the consumers would be willing to buy the indicated quantity at the indicated price, and the space to the right of the demand curve consists of points that are unattainable, i.e., consumers would not be willing to buy the indicated quantity at the indicated price.

Consumer Optimization

The derivation of an individual's demand curve begins with the set of indifference curves that describe the consumer's utility for two commodities. Figure 1.4 displays such an indifference

map in which the curves I_1 through I_3 describe the points at which a consumer is indifferent between the quantities of X and Y at different levels of income. Figure 1.4 also indicates the line describing the consumer's budget constraint that limits the consumer's ability to purchase commodities, line BB. In a simple two-good world, these limitations on purchasing power may be expressed in the form of a budget constraint equation:

$$XP_x + YP_y = R = Income$$

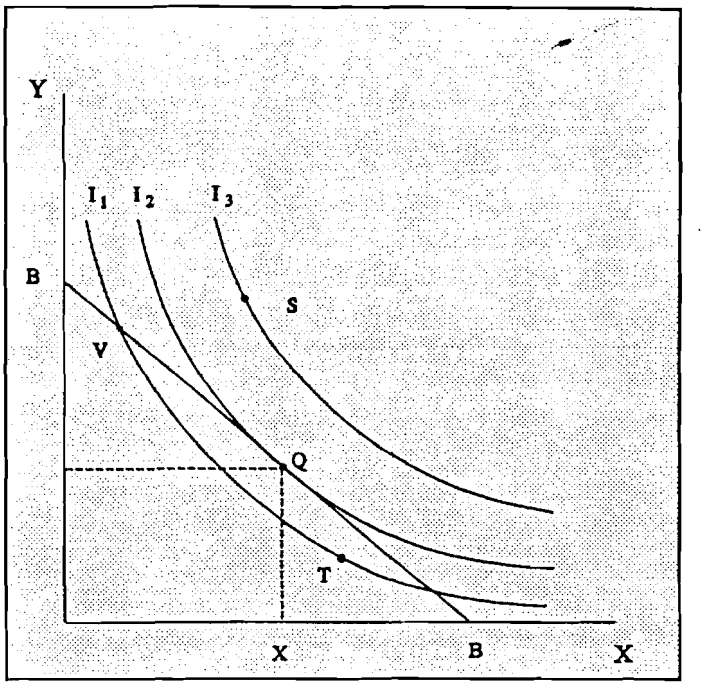


Figure 1.4: Consumer Indifference Map

When the consumer purchases all Y and no X, the maximum number of units of Y obtainable is R/Py. This is the vertical intercept in Figure 1.4. Similarly, if the consumer purchases all X and no Y, R/Px represents the maximum units of X obtainable, which is the intercept of the horizontal axis of BB in Figure 1.4. A consumer ordinarily will choose to buy some combination of goods rather than only one good; the alternative combinations available to the consumer may be visualized by connecting the two intercepts with a straight line, the slope of which is -Px/Py.

At point Q in Figure 1.4, the budget constraint is tangent to the indifference curve I_2. Choosing the combination of X and Y described by the commodity bundle Q yields the highest utility the consumer can attain, given income and prices. Notice that the consumer is also able to purchase commodity bundles V and T, but these bundles represent lower levels of utility. Commodity bundle S is not available since it costs more than the available income.

The slopes of the indifference curves are defined as the marginal rate of substitution of Y for X. It is the rate at which consumers are willing to trade Y and X at a constant level of income. Maximum utility is reached at the point where the budget line is tangent to the highest possible indifference curve. At this point, the price line and the indifference curve have the same slope, so the condition of maximum utility can be written as follows:

$$MRS_{xy} = \frac{P_x}{P_y}$$

The economic interpretation of this condition is that maximum utility is attained when the rate at

which the consumer is just willing to trade Y in order to obtain a unit of X (MRS_{xy}) is equal to the rate at which the consumer is able to trade Y for X (the price ratio).

Derivation of Consumer Demand

With a statement of the equilibrium conditions of consumer choice in hand, it is now possible to derive a consumer's reactions to changes in prices. This analysis leads, in turn, to the derivation of a consumer demand curve.

Figure 1.5a shows the impact of changes in the price of the commodity on consumer demand. Let the price of commodity X be the price that is changing. The budget line can then be written:

$$Y = \frac{R}{P_y} - X\frac{P_x}{P_y}$$

As P_x rises, the slope of the price line ($-P_x/P_y$) becomes a larger negative number--the price line becomes steeper. An array of price lines are drawn in Figure 1.5a. Again, the tangencies with indifference curves can be read off, and are connected by a curve called the price-consumption curve (PCC) or offer curve. The PCC curve records the different combinations of X and Y that the consumer will buy at different prices of X, holding income and the price of Y constant. The PCC curve has a negative slope indicating that the quantity of X purchased declines as its price rises (the basic "law of demand").

Using the above analysis, the demand curve, which records the maximum quantity of X that consumers will buy at different prices of X, holding the price of Y and income constant, can now be derived. When the price of X is equal to 2, point A′ is the consumer optimum and the consumer will purchase X_3 units of X. This point is plotted in Figure 1.5b. When the price of X is equal to 3, point B′ is the consumer optimum and the consumer will purchase X_2 units of X. Thus points A′ B′ C′, and all others not shown are quantities of X demanded at different prices, where all other significant impacts on demand, such as income, the price of Y, and consumer preferences, are held constant. The collection of such points forms the *income compensated* demand curve, labeled D in Figure 1.5b.

Unfortunately, the demand curve just derived is not the one obtained by recording a consumer's *observed* purchases of a commodity as prices change. The problem is that while *nominal* income R can be held constant when the price of a commodity declines, the amount of income available for purchasing all commodities increases as a direct consequence of the price change. In other words, any relative price decrease causes a consumer's purchasing power or *real* income to increase. The demand curve derived in Figure 1.5b has ignored this last effect since the income effect of a price change cannot be easily separated from the price change that brought it about. The *ordinary* demand curve used in empirical analysis therefore includes both the relative price effects and the real income effects. However, unless the expenditures on the good, and the price variations in question are large relative to the consumer's income, the error in using a directly observed ordinary demand curve in empirical analysis will be small. For this reason, in policy analysis and in applied welfare analysis, the use of ordinary rather than income compensated demand curves is widely accepted.

The Market Demand Curve

The slope and position of the industry demand curve, can, like the industry supply curve, be derived from an aggregation of individual consumer choices. Once the individual demand curves are derived from the indifference maps of each consumer, the market demand curve is obtained by horizontally summing over the individual demand curves.

In Figure 1.6 the demand curves d_1 and d_2 represent demand for the only two households in a particular market. Each point on the market demand curve D is the result of a horizontal sum of individual quantities demanded at a given price. Thus, added horizontally, $A = a_1 + a_2$ at price P_1 and $B = b_1 + b_2$ at price P_2. Plotting all points such as A and B defined the market demand curve, labeled $D = \Sigma_h d$.

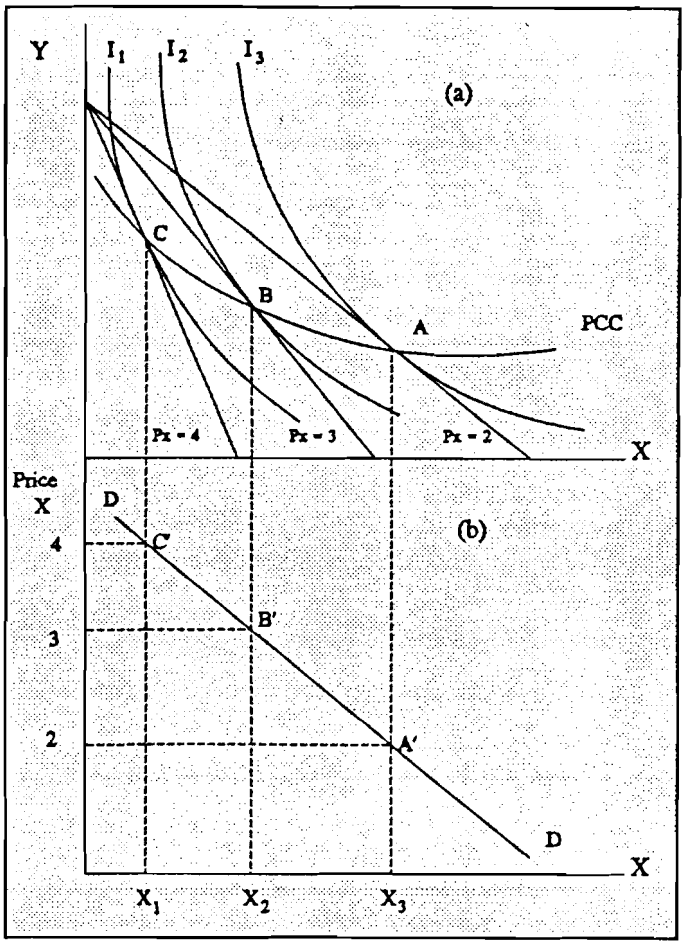


Figure 1.5: Derivation of Individual Demand Curves

Demand Elasticities

Demand elasticities are similar to the supply elasticities discussed earlier in that they are a ratio of relative changes in price to the corresponding ratio of relative changes in quantity consumed. The price elasticity of demand depends primarily on consumption substitutes. Consequently, the more narrowly the commodity in question is defined, the more substitutes will be available and the greater will be the price elasticity of demand for the commodity. It is usually assumed that, in the course of changing a policy, the quantity of resources owned by different individuals is fixed and so a particular set of factor prices is taken as determining the income and wealth of the individual consumers. Similarly, tastes and preferences are regarded as fixed. Thus, formulas for computing the elasticity of demand are the same as those shown in the previous section on supply elasticities. However, it must be remembered that there is a difference in the sign of the coefficient. When price increases, quantity decreases. The price elasticity of demand is therefore negative. If the elasticity is -1, it is called a *unitary* elasticity. (Such a curve--a rectangular hyperbola--will produce a 10 percent decline in quantity for a 10 percent increase in price.) If the elasticity is numerically greater than a -1, for instance, -2, the demand is called *elastic*. This means that for a 10 percent change in price, there will be a greater than 10 percent change in quantity. If the elasticity is numerically less than -

1, for instance, -0.5, the demand is *inelastic* and a 10 percent change in price will bring about a smaller percentage change in quantity.

Consumer Surplus

The notion of consumer surplus is straight forward. The demand function shown in Figure 1.7 represents the various quantities that consumers are willing to buy at different prices. A perfectly discriminating monopolist, by definition, would extract as revenue the whole area under the demand curve by selling to individual customers at sequentially lower prices. But in a competitive market producers must sell all units of the commodity at the same price. Therefore, the area under the demand curve and above the price line is "surplus" (unspent income) of consumers; consumers are able to obtain a unit of the commodity at a price which is less than their marginal willingness to pay for it. In Figure 1.7, at price P_2, consumer surplus is the shaded area A. If the price falls to P_1 and consumption increases from Q_2 to Q_1, consumers gain an additional surplus equal to area B + C. Consumers, therefore, gain from a price fall provided that the demand function slopes downward.

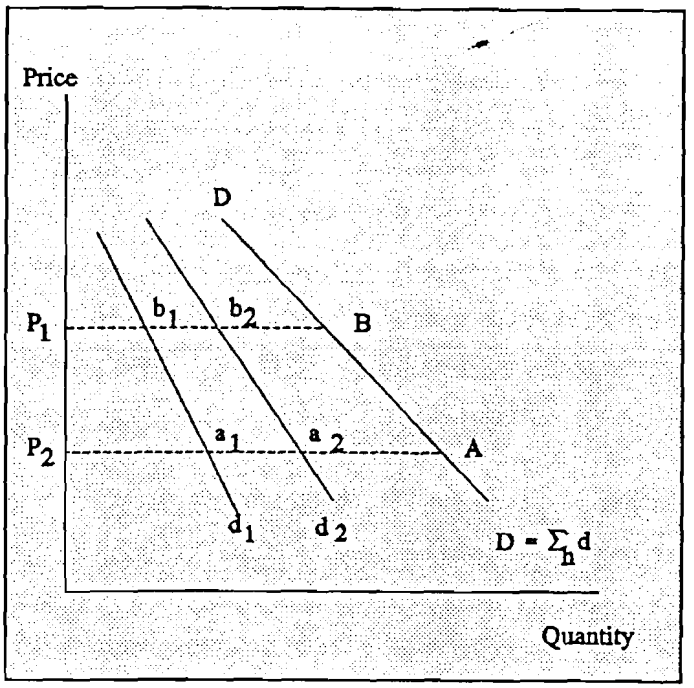


Figure 1.6: The Market Demand Curve

LIMITATIONS OF SURPLUS MEASURES

While the use of surplus measures in policy analysis is quite common, their use requires acceptance of several restrictive assumptions. For example, imlicit in all surplus measures is the assumption that a person's money or real income is a reasonable index of individual well-being. Surplus measures cannot account for the fact that an individual may derive satisfaction from such things as leisure as an alternative to maximizing income. Surplus measures should therefore be thought of as only approximate indices of a individual's well-being.

A more serious limitation of surplus measures is that they are technically only suitable in a perfectly functioning environment, i.e. one in which there are no further distortions in the economy preventing individuals from exploiting all opportunities for mutual gain. If this assumption does not hold, analyses of *n*th best worlds in which numerous distortions exist have shown that no unequivocal welfare conclusions can be drawn.

A final important limitation of surplus measures is that while economic theory demonstrates that

92

the maximization of producer and consumer surplus will lead to the most efficient outcome in a perfectly competitive environment, such an outcome *may not* be the most equitable one in a normative sense.[4] The problem is that the outcome actually achieved depends upon the initial pattern of ownership of society's primary factors of production among the households of the economy. If these factors of production are initially distributed unequally, the efficient outcome may be even more inequitable. If income distribution is a policy goal, the analyst may want to disaggregate the gains and losses due to a policy change by income group. There are potentially a large number of efficient allocations of resources in the economy, each associated with different patterns of factor ownership and different levels of well-being in the economy's various households. Maximizing surplus measures only finds the efficient outcome for a given pattern of ownership of factors of production. It does not indicate how society's resources should be allocated among households initially.[5]

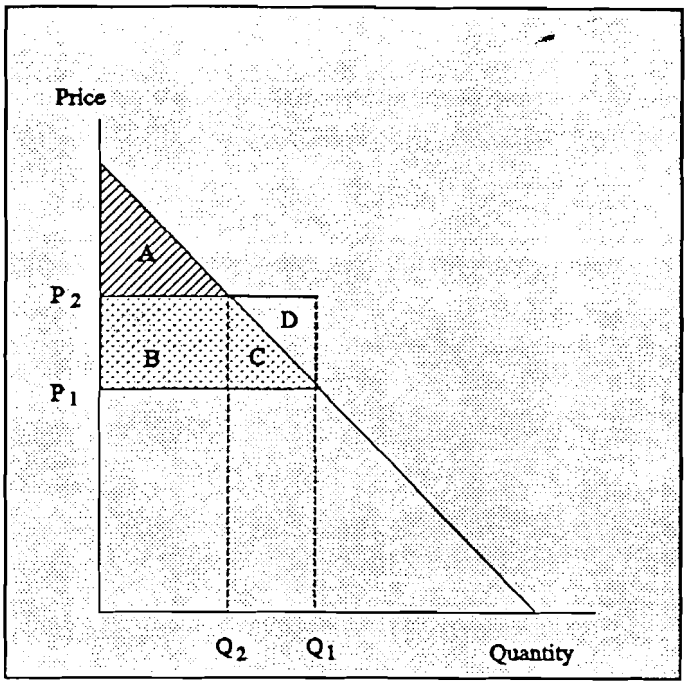


Figure 1.7: Consumer Surplus

Despite these limitations, surplus measures are widely used in policy analysis because they are relatively easy to calculate and easy to interpret. Most importantly, they do provide a broad indication of which groups benefit and which groups are made worse off as a result of changes in world market conditions or changes in government policy.

ANALYZING MARKET INTERVENTIONS

The definition of supply and demand curves for a commodity opens the way for a discussion of market equilibrium. The graph in Figure 1.8 shows the traditional intersection of supply and demand curves for a commodity in which the equilibrium price is determined in a market *without*

[4] This statement assumes that the feasibility of costless lump-sum payments to make the efficient outcome also more equitable, is limited.

[5] For a thorough treatment of the theory and assumptions underlying applied welfare economics see, Robin W. Boadway and Neil Bruce, *Welfare Economics*, Basil Blackwell Publisher Limited, Oxford, England, 1984. See also Isabelle Tsakok, *op. cit.* pp. 137-138.

reference to trade.

Suppose the supply and demand model is given by the following three equations:

$S = D$ *Market clearing*
$S = a + bP$ *Supply equation*
$D = c - dP$ *Demand equation*

Finding the point of intersection between these two lines can be done in several ways. In the single commodity model, simple graphing techniques can be used. For example, by using a spreadsheet or a calculator, values for S and D can be computed for a range of prices, and the equilibrium price that equates the marginal utility of consumers with the marginal costs of producers can be read from the graph. The solution can also be found algebraically by simple substitution or, as Chapter 4 demonstrates, a spreadsheet's matrix inversion capabilities can be used in the multi-market case.

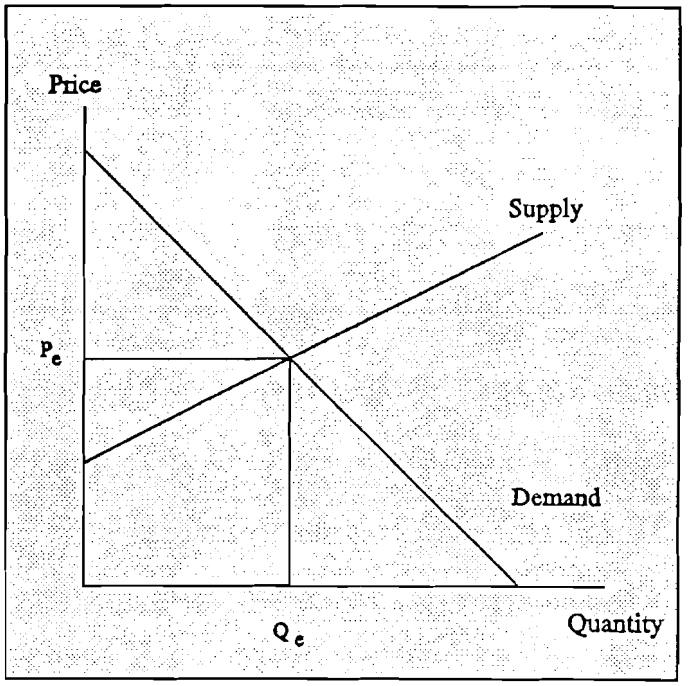


Figure 1.8: Supply-Demand Equilibrium

Although endogenously determined agricultural commodity prices can be found in most economies, commodities whose prices are determined exogenously by government policy or by trade on international markets are likely to be even more important. Price exogeneity actually stimulates rather than dampens the need for multi-market analysis because it means that, in the presence of significant cross price elasticities, the impact of trade or policy related price changes in one market must be absorbed to a greater extent by quantity adjustments in that market. Such a result will be demonstrated in Chapter 3.

The initial exercises in Chapters 2-3 illustrate the welfare implications of price policy interventions when the adjusting variables are the quantities produced, consumed, and traded. An example of this type of approach is presented in Timmer, Falcon and Pearson (p.191-193) in which the authors analyze the impact of a subsidy on Indonesian rice.

Figure 1.9 illustrates the effect of a consumer subsidy (cum producer tax) on rice from the perspective of the government. In the example, the government is setting the domestic price of rice to both producers and consumers below the border price, causing domestic rice consumption to increase, and domestic production to decline. The deficit ($Q_4 - Q_2$) must be purchased by the government at world prices and then resold to consumers at the lower domestic price. In order to

do so, it incurs a budgetary cost shown by the shaded area in the diagram. The area is equal to the subsidy on each unit (P_w - P_d) times the number of units imported (Q_4 - Q_2).

Figure 1.10 examines the policy from the producers' point of view. Obviously, due to the lower price received by producers, producer surplus has been reduced. Without the tax, producers would be earning total rents (profits) equal to the area ACJ. At the lower domestic price, however, producers only earn rents equal to the area FGJ. The difference - the shaded area ACGF - represents the loss in producer surplus due to the tax. From the economy's point of view, the reduction in production from Q_1 to Q_2 is inefficient. In the absence of the tax, producers could produce the (Q_1-Q_2) amount of rice at a cost equal to the area Q_1Q_2GC; yet with the policy the government is having to import this amount of rice at the world price at a total cost equal to Q_1Q_2BC. The difference, the triangular area BCG, is the additional cost to the economy of importing rice at a higher opportunity cost than domestic production. This triangle is commonly labeled the "production efficiency loss" of the rice subsidy.

Figure 1.11 shows the effects of a consumer subsidy on rice. Consumers are clearly better off; consumer surplus has increased by the area under the demand curve between P_w and P_d, i.e., the striped area ADHF. However, to generate this increase, the government was required to expend an amount equal to the area DEQ_3Q_4--the cost of importing this rice at world prices. This amount is larger than the consumers marginal willingness to pay

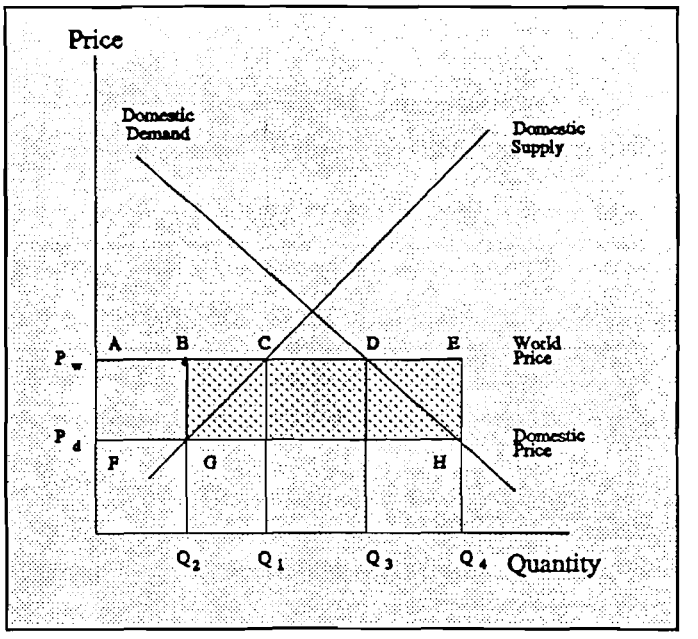


Figure 1.9: Government's Perspective

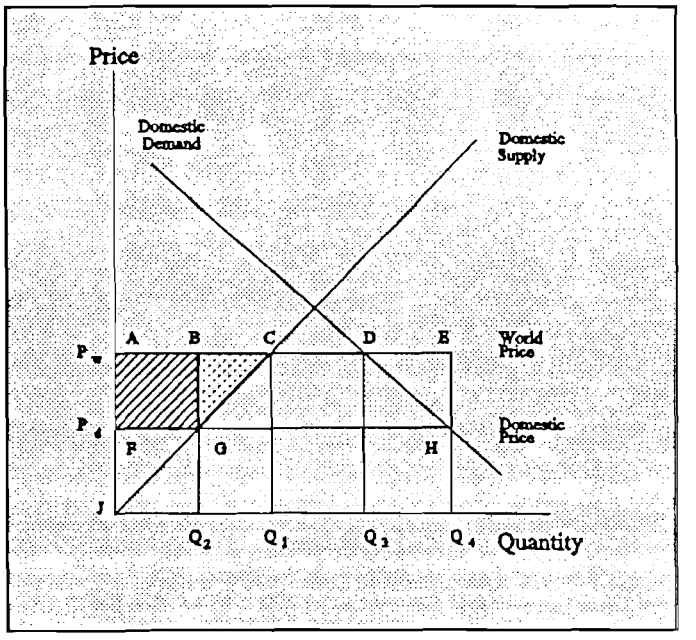


Figure 1.10: Producer's Perspective

for the additional consumption equal to area Q_4Q_3DH. The difference--the triangle DEH--illustrates the excess the economy had to pay for the extra consumption over and above what consumers were willing to pay. This triangle is often labeled the "consumption efficiency loss" of the rice subsidy.

Figure 1.11 also makes it clear that only a portion of the subsidy to imported rice is coming from the government. The remainder, i.e., the area ACGF, is a transfer from producers to consumers. This aspect of maintaining low food prices, often supported by concessional sales from developed countries in their foreign aid programs, has had profound negative effects on agricultural output in many developing countries.

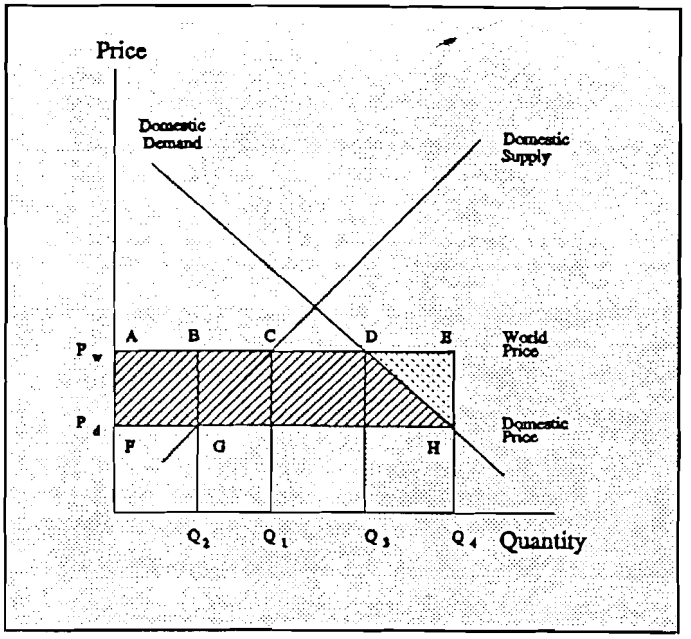


Figure 1.11: Consumer's Perspective

The above example illustrates the power of simple market level models in which, because prices are exogenous, adjustments to policy take place entirely through adjustments in commodity trade.

PAMS vs. MARKET LEVEL ANALYSIS

Another volume in this series provides an example of the PAM (Policy Analysis Matrix) approach developed in the text by Monke and Pearson.[6] The following section provides a brief comparison between the PAM and market level approaches and discusses the strengths and weaknesses of each.

As demonstrated, the market level model in the previous section calculates the impact of output price policy on the quantities produced, consumed and traded of a single commodity, and the impact on the government budget. Moreover, the model addresses the distributional impact of price policy between consumers, producers and taxpayers, and the deadweight efficiency losses that arise from distorting price policies.

In contrast, the PAM approach to policy analysis examines the impact of price policies on the

[6] Eric Monke and Scott Pearson, *The Policy Analysis Matrix in Agricultural Development*, Cornell University Press, 1989.

costs and returns of agricultural production and how per unit profits change as input and output prices are altered. The strength of a PAM stems from its use of disaggregated crop budget data which allow the straightforward identification of the sources of policy distortions affecting profitability.

Yet by focusing on profits rather than supply response directly, PAMs provide little indication as to how quantities produced may adjust to price changes. Furthermore, because a PAM framework does not incorporate the demand side, it does not provide information on the impact of price polices on consumption, and therefore trade. Of course, without the demand side, the distributional impact between producers and consumers of price policy also cannot be addressed.

The market level approach is also subject to several limitations. One problem associated with this class of models is their heavy reliance on elasticities which, at best, are only guides as to how producers and consumers respond to prices. For example, because elasticities are often measured using historical data, they reflect past behavior and may therefore be inadequate for predicting behavior under new and different policies. Moreover, the information required to determine whether the elasticity is a partial or a total estimate may not be readily available. Finally, market level approaches depend upon *point* elasticities which provide no information on the true shape of the supply or demand curve. Hence, market level models are technically a legitimate guide only for *small* changes in policies (points near which the elasticity was measured).

A second important limitation of single commodity market models that employ partial elasticity estimates is their failure to account for multi-market effects. Multi-market effects are the *indirect* effects of policy and the *feedback* effects from other markets which arise because of the linkages of the commodity being analyzed with other commodities and with factor markets. For example, when two commodities are substitutes in production (i.e., they compete for the same resources), a single market analysis of either of the two commodities will overstate the impacts of any price change on the market being analyzed and will not provide any information on the impact of the policy on the other market.[7] Chapters 3-5 focus specifically on incorporating multi-market effects.

There are strengths and weaknesses to both the PAM and market-level approaches to agricultural policy analysis. The decision as to which framework to use ultimately depends on data availability and the questions being addressed.

---

[7] Note, however, that the impacts on the commodity market under investigation will *not* be overestimated if total elasticities are used in the analysis. This result is demonstrated in Chapter 4.

CHAPTER 2: ANALYSIS OF A SINGLE COMMODITY MARKET

The preceding chapter dealt with the conceptual framework of market level analysis. This chapter develops examples of a variety of single commodity interventions in the Philippine rice market. It shows how the impact of policy on efficiency, the government budget and the welfare of producers and consumers can be measured. Before turning to the computations, however, the following section suggests ways in which the exercises can be organized on a spreadsheet.

ORGANIZING MARKET LEVEL MODELS ON A SPREADSHEET

Table 2.1 illustrates the principal table used in this Chapter. As the instructions in the next section indicate, tables are identified by the use of the *Range/Name/Create* command which names each table, and by the use of the *GoTo* command (F5) which permits users to go directly to the table of interest. When these two commands are used together, it no longer matters where the table is located on the spreadsheet since finding it is simple.

Maximum flexibility in spreadsheet applications can be maintained by organizing tables on a diagonal. Each successive table is placed below and to the right of the preceding tables. This arrangement, sometimes called the "diamondback" method, makes it possible to make alterations to the computations of any one table by simply inserting or deleting rows and columns. So long as these spreadsheet commands are used (they are virtually the same for all vendors), the computer will adjust cell addresses used to calculate various cell formulas to reflect the change of the table's dimensions. It is important that the addition or deletion of rows and columns be done in this way. If row and columns are simply added or subtracted, tables will quickly overlap and changes cannot be made in one table without interfering with other tables.

Typically, a spreadsheet model contains separate blocks for *assumptions and data, computation, and reports*. In the following exercises, the organization will be somewhat different. Each model begins with an Assumptions and Data block, but then continues with a series of blocks that illustrate a particular type of agricultural policy intervention. For example, the first exercise investigates the impact of a production tax on production, consumption, welfare and the government budget. Following that, the effects of a consumer subsidy are modeled. Subsequently, a combination subsidy intervention on both producers and consumers is considered together. Finally, the model is used to investigate the impact of a tariff, and the equivalency between a tariff and a quota is discussed.

Each exercise contains both the instructions required to implement the model on the spreadsheet and a figure that shows graphically the arithmetic computations being made. Being able to move easily between two-dimensional graphs and the arithmetic on the spreadsheet is one of the attractive features of single commodity market level models. These tools are obviously no longer available when multi-commodity computations are employed, but the graphic approach is important in developing an intuition about how market level modeling works.

Table 2.1: Single Commodity Simulation

	A	B	C	D	E
1)	Exercise 2.1	Producer	Consumer	Combined	Tariff
2)	Comparison of policy instruments	Tax	Subsidy	Policy	Policy
3)					
4)	ASSUMPTIONS AND DATA				
5)	Supply elasticity	0.70	0.70	0.70	0.70
6)	Demand elasticity	-0.60	-0.60	-0.60	-0.60
7)	Initial Production ('000 mt)	22.00	22.00	22.00	22.00
8)	Initial Consumption ('000 mt)	35.00	35.00	35.00	35.00
9)	Initial net imports ('000 mt)	13.00	13.00	13.00	13.00
10)	World price ($US/mt)	55.00	55.00	55.00	55.00
11)	Exchange rate (P/$US)	3.80	3.80	3.80	3.80
12)	Foreign exchange premium (%)	0.00	0.00	0.00	0.00
13)	Equilibrium price of exchange	3.80	3.80	3.80	3.80
14)	Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
15)	Border price-market rate-(p/mt)	231.80	231.80	231.80	231.80
16)	Border price-equib. rate-(p/mt)	231.80	231.80	231.80	231.80
17)	POLICIES				
18)	Producer Subsidy Equivalent (%)	-10.00	0.00	10.00	10.00
19)	Consumer Subsidy Equivalent (%)	0.00	10.00	10.00	-10.00
20)	PRICES (pesos/mt)				
21)	Producer Price	208.62	231.80	254.98	254.98
22)	Consumer price	231.80	208.62	208.62	254.98
23)	Producer price change	-23.18	0.00	23.18	23.18
24)	Consumer price change	0.00	-23.18	-23.18	23.18
25)	QUANTITY EFFECTS ('000 mt)				
26)	Change in production	-1.54	0.00	1.54	1.54
27)	Change in consumption	0.00	2.10	2.10	-2.10
28)	New production level	20.46	22.00	23.54	23.54
29)	New consumption level	35.00	37.10	37.10	32.90
30)	Net imports	14.54	15.10	13.56	9.36
31)	Change in net imports	1.54	2.10	0.56	-3.64
32)	FINANCIAL ('000 pesos)				
33)	Change in prod. receipts	-831.23	0.00	902.63	902.63
34)	Change in con. expenditures	0.00	-373.20	-373.20	275.84
35)	Change in forex. costs	356.97	486.78	129.81	-843.75
36)	Budget costs (revenues)	-474.26	859.98	1405.64	-216.96
37)	WELFARE EFFECTS ('000 pesos)				
38)	Producer gain (loss)	-492.11	0.00	527.81	527.81
39)	Consumer gain (loss)	0.00	835.64	835.64	-786.96
40)	Efficiency loss in production	17.85	0.00	17.85	17.85
41)	Efficiency loss in consumption	0.00	24.34	24.34	24.34
42)	Total deadweight loss	17.85	24.34	42.19	42.19
43)	CHECK	0.00	0.00	0.00	0.00

ORGANIZING THE WORKSHEET

Enter Table 2.1 in the upper left hand corner of the spreadsheet. Put the table name, Exercise 2.1 at the top of Column A and identify it with *Range/Name/Create* command (e.g., EXER1). Save the worksheet and call it CHAPT2 before proceeding.

The ASSUMPTIONS AND DATA block describes a situation in which the market for rice in the Philippines is in equilibrium. World market prices prevail, i.e., producer, consumer and border prices are all the same. The result is that the country imports approximately 35 percent of its total consumption.

For the most part, the entries in the ASSUMPTIONS AND DATA block of the table are data; the exceptions are the entries for consumption, the equilibrium price of foreign exchange and the border prices. These data entries should be obtained by using the proper formulas. For example, if the worksheet has been set up identically to the one shown in Table 2.1, the formula to calculate consumption is +B7+B9 (production plus net imports); likewise, the formula for the shadow price of foreign exchange is +B11*(1+B12) (the exchange rate times 1 plus the foreign exchange premium). Finally, +B11*(B10+B14) (the exchange rate times the world price plus unloading costs) gives the border price at the market exchange rate, and +B13*(B10+B14) computes the border price at the equilibrium exchange rate.

$$\begin{aligned} M &= D - S && \textit{Market clearing equation} \\ S &= a + bP^P && \textit{Supply schedule} \\ D &= c - dP^c && \textit{Demand schedule} \end{aligned} \tag{2.1}$$

The basic single commodity model where the market clears through changes in exports or imports, consists of three equations. The coefficient of P, b, is the slope of the supply curve:

$$b = \frac{\Delta S}{\Delta P_r^P} = \frac{\partial S}{\partial P_r^P} \quad as \quad \Delta P \to 0 \tag{2.2}$$

and d is the slope of the demand curve:

$$d = -\frac{\Delta D}{\Delta P_r^c} = -\frac{\partial D}{\partial P_r^c} \quad as \quad \Delta P \to 0 \tag{2.3}$$

Because the analysis proceeds by examining *changes* in policy, the constants a and c can be ignored. The relevant equations for computing the impact of changes in prices on changes in quantities are

therefore:

$$\begin{aligned} \Delta S &= b\,\Delta P_r^P \\ &\textit{and} \\ \Delta D &= d\,\Delta P_r^c \end{aligned} \tag{2.4}$$

Very often, the numerical values of the slopes of the curves are not directly available. What are more commonly available are the elasticities which are the products of the supply or demand slopes times some "base year" or "initial" conditions, i.e.:[8]

$$E_s = \frac{\partial S}{\partial P_{ro}^P} \times \frac{P_{ro}^P}{S_{ro}} \tag{2.5}$$

$$E_d = \frac{\partial D}{\partial P_{ro}^c} \times \frac{P_{ro}^c}{D_{ro}} \tag{2.6}$$

where P^p_{ro} is the initial producer price for rice, P^c_{ro} is the initial consumer price for rice (P^p_{ro} = P^c_{ro} = world price P^w_r), S_{ro} is initial production, and D_{ro} is initial consumption.

In order to calculate ΔS and ΔD corresponding to a given change in price, the elasticity is multiplied by the base year conditions prevailing before the price change occurs. The results are given below.

[8] In time-series econometric estimation of elasticities, the "base-year" conditions are usually the average of the actual series used in the estimation.

$$\Delta S = E_s \times S_{ro} \times \frac{\Delta P^P_{ro}}{P^P_{ro}}$$

and (2.7)

$$\Delta D = E_d \times D_{ro} \times \frac{\Delta P^C_{ro}}{P^C_{ro}}$$

On the left hand side are the quantities to be determined, namely, the changes in supply and demand. The first term on the right hand side is the supply or demand *elasticity*. The second term is the initial quantity listed in the ASSUMPTIONS AND DATA block, and the third term is the percentage change in the base year price. Since the "new" prices are policy prices and so are exogenous, the change in quantity supplied and demanded can be calculated with knowledge only about the relevant elasticities and the initial prices and quantities.[9]

The final part of the computation, i.e., the determination of trade adjustments, is obtained from the market-clearing condition by substitution. The change in net imports is the difference between the change in quantity demanded and the change in the quantity supplied.

A PRODUCER TAX

Figure 2.1 illustrates a tax on rice producers. The government is assumed to implement this policy by procuring all domestically produced rice at a price lower than the world price, and by prohibiting all exports. The price that producers receive for the commodity is then assumed to decline by 10% as a result of the procurement scheme. By using the appropriate formula in 2.7, the decline in production can be determined. This amount must be made up with additional imports. It is assumed that the government is the sole purchaser of imports and sells these imports--plus what it has acquired from producers--to consumers at the old higher initial price P^w_r (the world price). The difference between the cost at which the product is acquired by the government from domestic producers, and the price at which it sells the commodity to domestic consumers, goes into the government's coffers.

The remaining blocks in Table 2.1 contain the necessary cells to investigate the impact of the price change. It is a generic table that is set up so that it can be used for a variety of computations. (To make subsequent instructions easier to understand, set up this first worksheet exactly as shown in Table 2.1.)

---

[9] Of course, it is highly unlikely that initial prices and quantities will be equal to the original values used to measure the elasticity. This is one limitation of borrowing elasticities from previous work, rather than estimating them directly. Nevertheless, since elasticities are, at best, only approximate indicators of how individuals respond to price changes, this problem is often thought relatively unimportant.

Step 1: Enter the policy prices.

The first cells under the POLICIES heading are data cells and their entries represent the impact of the policy intervention, in percentage terms, on the prices received by consumers and producers. For example, an entry of -10 next to the Producer Subsidy Equivalent heading indicates that the government is levying a 10% tax on producer prices.[10] These values should be entered directly by typing in the appropriate numbers. Enter the value -10 next to the Producer Subsidy Equivalent heading, and 0 next to the Consumer Subsidy heading.

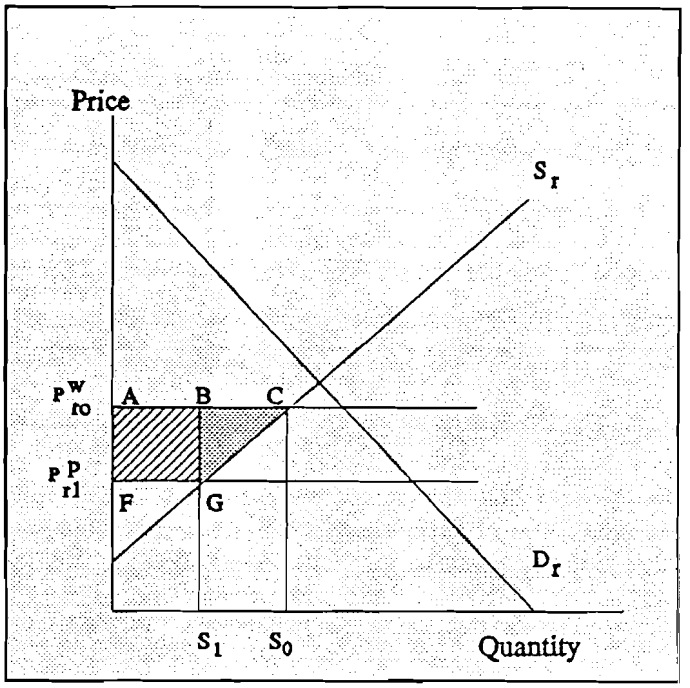


Figure 2.1: Base Case and Producer Tax

Step 2: Compute absolute price changes.

The second block, PRICES, calculates the absolute changes in prices due to the policy intervention. Using cell addresses, enter the formula for calculating the price farmers now receive as a result of the 10% tax. The correct formula is +B15*(1+B18/100). Although consumers are neither taxed nor subsidized in this example, the appropriate formula, +B15*(1-B19/100), also should be entered at this time. (Note the negative sign in the formula for consumers.) In so doing, the worksheet can be used later to analyze price policies that affect consumers. Then proceed by entering the formulas to compute the absolute change in both producer and consumer prices due to the tax. The formula to calculate the producer price change is +B21-B15; for consumers the formula is +B22-B15.

Step 3: Compute quantity changes.

As indicated above, the change in S is given by:

[10] The Producer Subsidy Equivalent attempts to capture in a single measure the total tax or subsidy levied on a commodity. This includes explicit output and input subsidies as well as indirect taxes and implicit subsidies. The Consumer Subsidy Equivalent is a similar inclusive measure applied to the demand side. For a discussion of the calculation of PSE's and CSE's, see Tsakok, *Agricultural Price Policy*, pp 96-101.

BEST AVAILABLE COPY

$$\Delta S = E_s \times S_{ro} \times \frac{\Delta P_{ro}}{P_{ro}} \qquad (2.8)$$

In words, the change in supply is equal to the elasticity of supply times the initial quantity supply times the percentage change in the initial price. Using the cell addresses given in the above table, the value of the cell indicating the change in production due to the tax is +B5*B7*B23/B15. Production declines by 1,540 mt since farmers reduce their output in response to the tax. The same basic formula applies for calculating the change in consumption, +B6*B8*B24/B15. Note that consumers continue to purchase the same amount; they are unaffected by the production tax.

Step 4: Compute new values for production, consumption and net imports.

The new level of production after the policy intervention is given by adding the change in production to the initial production level given in the ASSUMPTIONS AND DATA block. Using the cell addresses given in Table 2.1, the formula for "new" production level is +B7+B26. Consumption remains the same because the government continues to sell rice to consumers at the old border price. Do not, however, simply type the number 35 for consumption or copy the cell address for this amount from the ASSUMPTIONS AND DATA block. Remember, the idea behind building a good spreadsheet model is to make it as flexible as possible so that various types of policy interventions can be subsequently analyzed with *few or no adjustments* to the original table. The correct formula for the new level of consumption is therefore +B8+B27.

The new level of imports is obtained from the market-clearing equation M = D - S. Total net imports are given by the formula +B29-B28. As expected, the value for net imports is equal to the decline in production since consumer prices have not changed. The change in net imports is +B30-B9.

Step 5: Compute the financial implications of the producer tax.

The following block of financial calculations provides a variety of information of interest to policymakers.

a) Change in producer receipts.

The change in producer receipts is the difference between the gross revenue producers earned in the absence of intervention, and what they earn after the tax is imposed. A positive computation indicates that the policy increases producer gross revenue and a negative value indicates a decline in producer receipts. Since gross revenue is defined as the producer price times the amount produced, the formula to calculate the *change* in producer receipts is +(B28*B21)-(B7*B15). In this example, the producer tax results in a decline in producer receipts since both the price farmers receive, and the amount they produce decline.

b) Change in consumer expenditures.

An analogous computation can be done for consumers. The change in consumer expenditures is the difference between their total expenditures in the absence of policy, and what they spend in the presence of policy. A positive computation indicates an increase in consumer expenditures and a negative value indicates a reduction in total expenditures. Since consumer expenditures are defined as the price consumers pay times the amount they consume, the formula to calculate the *change* in consumer expenditure is +(B29*B22)-(B8*B15). The formula should return a value of zero in this example because consumers are unaffected by the production tax.

c) Change in foreign exchange (Forex.) costs.

Of special interest to finance ministries is the impact of the policy on foreign exchange expenditures. Since foreign exchange is used to purchase imports, the cost of the policy in terms of foreign exchange is equal to the change in imports times the border price at the market exchange rate. A positive entry indicates an increase in foreign exchange requirements due to the policy; conversely, a negative value indicates that the policy saves foreign exchange.[11] The correct formula is +B31*B15. (Note that formula reports the foreign exchange costs (savings) in terms of domestic currency. Since imports have increased because of the producer tax, so do foreign exchange expenditures. To report the change in terms of foreign currency, simply divide the formula by the exchange rate, B11.)

d) Budget costs (revenues)

Up to now, the government's rationale for implementing a producer tax has not been discussed. One possible motivation is the need to raise revenue, particularly since the income raised from the tax is not passed on to consumers. The amount raised is equal to the product of the per unit tax on production and the amount produced at the lower price level.

The same type of calculation is repeated to compute any impact on the government's budget due to changes in consumer prices. In this case, consumers are neither taxed nor subsidized. However, in the interest of building a flexible worksheet, the appropriate formula should be included. The portion of government revenue originating from consumers is the product of the change in the consumer price and the amount consumed at the new price level.

With these two elements in hand, the correct formula to calculate the impact of the production tax on the budget is +(B23*B28)-(B24*B29).

---

[11] Notice that the accounting convention where savings would be represented as a positive number and costs as a negative number is not employed in this instance (nor in the subsequent calculations of budgetary impact and efficiency losses). By not adhering to this convention, the formulas used to calculate the impact of a producer tax can also be used to compute the impact of other policies - no changes will be required.

Step 6: Compute the welfare effects of the producer tax.

a) Producer gain/loss.

As Fig. 2.1 illustrates, a tax on production lead to a loss of producer surplus (profits) equal to the area ACGF. This loss can be broken down into two parts:

(a) the loss of profits on the amount of crop that continues to be grown, area ABGF;

(b) plus the loss of profits on the amount of the crop that was previously grown, area BCG;

One way to compute the loss in producer surplus is to use the appropriate cell addresses to compute the areas indicated in (a) and (b) above. The problem with this method is that it will lead to the correct result (both in magnitude and in sign) only if the order of subtraction of the prices and quantities is correctly specified. In other words, one has to be very careful to ensure the formulas yield the right signs.

Fortunately, by simple algebraic manipulation, the sum of the above formulas can be shown to be equal to $(P^{p}_{r1}-P^{w}_{r})*(S_0+S_1)/2$. (Check for yourself.) Using this formula eliminates any potential sign problems because it returns a negative value if producer surplus declines and a positive value if producer surplus increases. This is the way producer losses and gains are designed to be reported on the worksheet. For this reason, the use of the above formula, +B23*(B7+B28)/2, is highly recommended. (Note that the formula using cell addresses takes advantage of the previous calculation of the producer price change reported under the PRICES block.)

b) Consumer gain/loss.

The producer tax on rice does not lead to a change in consumer surplus because the "new" price and quantity estimates for consumers are also the "old" values. Nevertheless, the appropriate formula should be added at this time in anticipation of future exercises. Using the same logic as in (a) above, the change in consumer surplus can be calculated as -B24*(B8+B29)/2. **(Do not forget the negative sign!)**

c) Efficiency loss in production.

As Figure 2.1 shows, domestic production has declined. In the absence of the tax, producers could have produced S_0-S_1 at a total cost equal to the area S_0S_1GC. With the policy, the government has to import rice at the world price at a total cost equal to S_0S_1BC. The difference, the triangular area GBC, is the additional cost to the economy of importing rice at a higher opportunity cost than domestic production. Using the cell addresses given in Table 2.1, 0.5*@ABS(B21-B15)*@ABS(B28-B7) gives the value of the triangle. (The use of absolute values ensures that losses will always be reported as positive numbers - see footnote 10.)

d) Efficiency loss in consumption.

In this example, the producer tax on rice does not lead to an efficiency loss in consumption because consumers continue to purchase rice at the world price. Again, in the interest of constructing a flexible spreadsheet, the appropriate formula, 0.5*@ABS(B22-B15)*@ABS(B29-B8) should be entered. The formula should return a value of zero.

c) Total deadweight loss.

The total deadweight loss is the sum of the production efficiency loss and the consumption efficiency loss. This amount represents how much society as a whole is losing, in monetary terms, from implementing a distorting policy. As we shall see, the total efficiency loss can also be viewed as the portion of the producer tax revenue that is not transferred either to the government or to consumers. The correct formula for the total deadweight loss when producer and consumer welfare gains and losses are reported as positive numbers is +B40+B41.

Step 7: Check the results

A quick glance at the calculations made thus far indicates that the loss in producer surplus (profits) is not entirely transferred to the government. The difference between what producers lose and what is transferred to the government *is* the total efficiency loss to the economy of implementing the policy. Although certain groups gain and certain groups lose as a result of a move away from free markets, society as a whole is made worse off since resources are being allocated inefficiently. The total deadweight loss provides an indication, in monetary terms, of how much worse off the country is because of the distorting policy. If the formulas have been entered correctly thus far, the loss in producer and consumer surplus should be equal to the total deadweight loss of the policy plus the tax revenue the government collects. The results can be checked by entering the formula @ABS(B38+B39)-@ABS(B42-B36). The result should equal zero. (Incidentally, this would be a good time to save your spreadsheet!)

A CONSUMER SUBSIDY

The market level analysis continues with the investigation of a subsidy on consumption. Figure 2.2 describes the situation graphically. In this exercise, the government is assumed to purchase all domestic production and imports at the world price and sell the total amount to consumers at 10% below the purchase price. The consumer subsidy is represented graphically in Fig. 2.2 by the gap between P^w_r and P^c_r. The government budget bears the cost of the total subsidy on the amount consumed, since producers continue to receive the border price.

The consumer subsidy problem can be implemented by copying both the data in the Assumptions and Data block, and the formulas used in the previous problem, to the column next to itself. As shown in Table 2.1, label this column "Consumer Subsidy".

The first step requires entering the 10% percentage decrease in the consumer price under the POLICIES block. Enter a *positive* value of 10 next to the Consumer Subsidy Equivalent heading since a price decrease to consumers represents a subsidy, not a tax. Also enter the value zero next

to the Producer Subsidy equivalent heading since producers are neither taxed nor subsidized in this example.

All subsequent computations will be automatic as soon as these new price changes are entered. Because the formulas are flexible, the worksheet correctly reports the impact of a consumer subsidy on the volumes produced, consumed and imported, in addition to the impact on the budget and welfare, without any further alterations.

As anticipated, a consumer subsidy increases the amount consumed and therefore imported. The policy also costs the government 860,000 pesos to implement, an amount that is not transferred entirely to consumers. The difference is the total deadweight loss of the policy, area DEH in Figure 2.2.

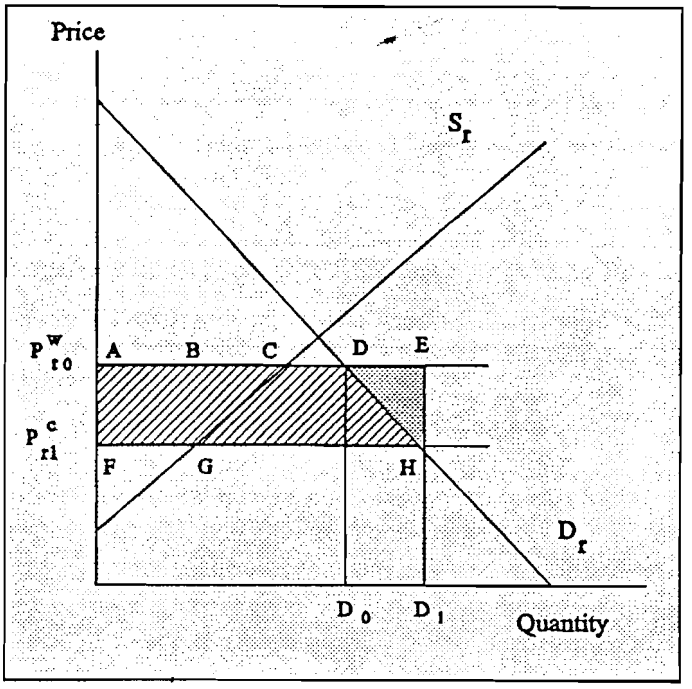


Figure 2.2: Base Case and Consumer Subsidy

COMBINED PRODUCER-CONSUMER INTERVENTIONS

Thus far interventions in a single commodity market have been taken isolation. In reality, there are often multiple interventions resulting from policies administered by different organizations in the government. For example, the Ministry of Agriculture, with its focus on production problems, imposes taxes, subsidies or regulations on producers. The Ministry of Commerce, on the other hand, is primarily oriented toward consumers and hence its policies are directed at their welfare.

Figure 2.3 suggests such a problem. In this diagram, the government is subsidizing domestic production by procuring all output at a price higher than world market price equivalents. At the same time, the government is providing a subsidy to consumers so that they will not bear the burden of the higher domestic price. Of course, the government must also restrict private imports in this case; otherwise importers could profit from importing at the world price and selling to the government at the subsidized price. Such a combined subsidy program is an example of an extreme preoccupation with food security. When the government subsidizes the producer in order to obtain increased output and then subsidizes the consumer in order to provide cheap access to the commodity, the impact on the government budget is substantial. These types of policies are generally feasible only in the presence of substantial non-agricultural sources of government revenues.

BEST AVAILABLE COPY

Step 1: Enter the price changes

The first step should now be familiar. Copy the entire Consumer Subsidy column to the right of itself. Label this new column "Combined Policy" as shown in Table 2.1. Then enter a positive value of 10 next to the Producer Subsidy Equivalent heading to indicate that producers are now also receiving a 10% subsidy.

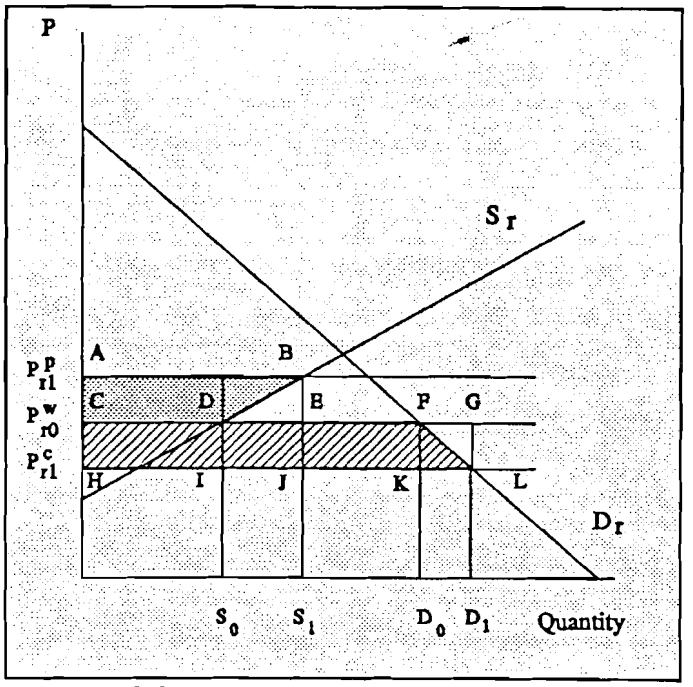


Figure 2.3: Producer and Consumer Intervention

Once again, due to the flexibility of the worksheet, the values in the column correctly represent the impact of a combined subsidy program on production, consumption, and imports as well as on the budget and welfare. Not surprisingly, the combined subsidy program has a substantial negative impact on the government budget. The total budgetary cost of this combined subsidy is shown in Figure 2.3 and is equal to ABEC + CEJH + EGLJ. Note that very little additional foreign exchange is required since the subsidy to producers increases production, thus offsetting most of the increase in demand due to the consumption subsidy.

TARIFF POLICY

Thus far the analysis of policy interventions has focused on the use of domestic taxes and subsidies to cause prices to diverge from their undistorted levels. Yet in order for the policies to have their intended effects, the government must control trade in the commodity. The above Combined Policy exercise is an example where the government would have to be restricting imports to prevent importers from purchasing at the world price and selling to the government at the higher subsidized price.

In some circumstances, governments prefer to not intervene in the market directly with procurement programs, but rather rely on trade policy exclusively. Two common trade policy instruments are tariffs and quotas. A tariff is nothing other than a border tax levied on imports. A tariff can be computed on an ad valorem basis whereby the tariff is calculated as a percentage of the border price. Alternatively, it can be computed as a flat tax - a rate quoted in absolute dollars per physical unit. This latter type of tariff is called a specific tariff.

Figure 2.4 describes the impact of a tariff policy. The tariff raises the domestic price to both consumers and producers above the world price; producers are subsidized and consumers taxed. At

BEST AVAILABLE COPY

the world price, (D_0 - S_0) would have been imported. At the new higher price only (D_1 - S_1) is imported, since the higher price causes consumers to purchase less and suppliers to produce more.

An alternative way for the government to achieve these results is through the use of a quota. A quota is a quantitative restriction on imports to some specified amount. A quota restricting imports to (D_1 - S_1) would raise domestic prices by the same amount as the tariff. Hence, the two instruments are said to be "equivalent." The only significant difference between them is who receives the revenue generated from the policy. With a tariff, the government receives the tax revenue. With a quota, imports can be restricted either by prohibiting the private sector from importing the commodity with the government then assuming that role, or by issuing quota permits to the private sector for the amount (D_1 - S_1). If the government does the importing, it receives the rent. This is the profit from being able to import (D_1 - S_1) at the world price and selling that amount to consumers at the higher domestic price. If the government chooses to issue quota permits to the private sector, then the recipients of the permits receive the rent.

As before, copy the data and results of the previous exercise to the right of itself. Label this new column 'Tariff Policy' as shown in Table 2.1. In this exercise, the government is imposing an ad valorem tariff of 10%. Enter 10 next to the Producer Subsidy Equivalent heading and -10 next to the Consumer Subsidy Equivalent heading.

Once again, the impact of the tariff policy on consumption, production, imports, the budget and welfare are all correctly reported. Imports decline as expected and the government earns the tariff revenue. Producers are better off since they receive a higher price; consumers are worse off for the same reason.

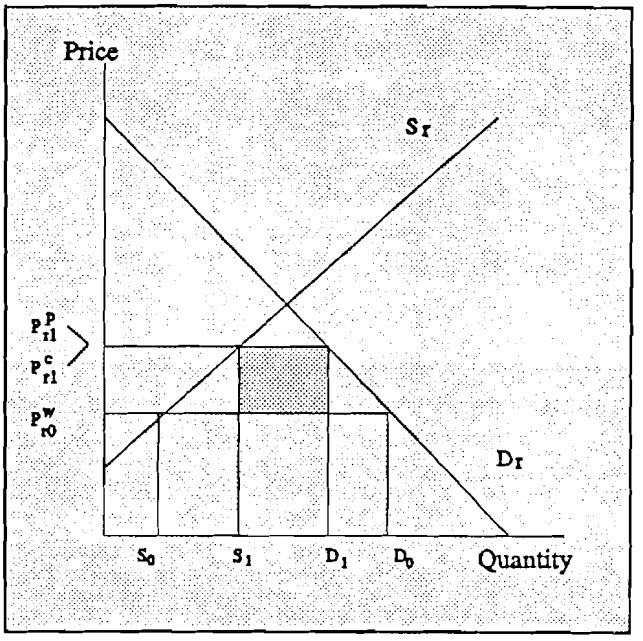


Figure 2.4: Tariff Policy

SENSITIVITY ANALYSIS

Elasticities

The effects of changes in assumptions about any of the parameters in the Assumptions and Data block can be easily examined with the "what if" capabilities of the spreadsheet. Two areas of particular interest are assumptions about the elasticities that were used and the assumption about the equilibrium exchange rate.

Table 2.2 presents the results of changing the assumption about the elasticity of supply on the Tariff Policy Intervention analysis. To perform this exercise, copy the entire table just completed

BEST AVAILABLE COPY

100

down and to the right of itself so that it is separated by at least a column and a row. Label this new table "Exercise 2.2 - Sensitivity to Elasticity Values." On the new worksheet, copy the tariff policy column over the other policy exercises so that all four columns are identical.

To examine the sensitivity of the results to changes in the elasticity values, reduce the supply elasticity by .1 in each of the columns after the first. The supply elasticity in the second column will now be .6, and will be .5 in the third column, etc. One interesting result that emerges is the

relationship between the total deadweight loss of a tariff and the size of the supply elasticity. As the results indicate, the higher the supply elasticity, the greater are the deadweight losses from a tariff policy. Why?

Tariff Height

One can think of many types of "what if" analyses to perform and the design of the worksheet makes the task quite easy. The following exercise suggests a perhaps less obvious sensitivity test - one that examines the relationship between the size of the tariff and the total deadweight loss.

To perform this analysis, proceed as before by copying Exercise 2.2 (the heading and the four tariff columns) down and to the right of itself on the diagonal. Label this new exercise "Exercise 2.3 - Tariff Height and Economic Cost". Be sure to return all supply elasticities to their original value of .7. Table 2.3 shows the impact of raising the tariff by 5% successively. Why does the deadweight loss increase at a much faster rate?

TRACING SUPPLY AND DEMAND CURVES

Note that the facilities of the spreadsheet also make it possible to trace out supply and demand curves. To draw Figure 2.5, first copy Exercise 2.1 down and to the right of Exercise 2.3 - "Tariff Height and Economic Policy". Name it Exercise 2.4 - "Tracing Demand and Supply Curves." Under the POLICIES block, enter four Producer Subsidy Equivalents: 1, 5, 10, and 15. Enter Consumer Subsidy Equivalents -15, -10, -5 and -1. These amounts represent different combined policy exercises. The combined policy exercise is used because in order to trace supply and demand curves, both supply and demand must be reacting to price changes.

Table 2.2: Sensitivity Analysis of Elasticity Values

Exercise 2.2 Sensitivity to Elasticities	Tariff Policy	Tariff Policy	Tariff Policy	Tariff Policy
ASSUMPTIONS AND DATA				
Supply elasticity	0.70	0.60	0.50	0.40
Demand elasticity	-0.60	-0.60	-0.60	-0.60
Initial Production ('000 mt)	22.00	22.00	22.00	22.00
Initial Consumption ('000 mt)	35.00	35.00	35.00	35.00
Initial net imports ('000 mt)	13.00	13.00	13.00	13.00
World price ($US/mt)	55.00	55.00	55.00	55.00
Exchange rate (P/$US)		3.80	3.80	3.80
Foreign exchange premium (%)	0.00	0.00	0.00	0.00
Shadow price of foreign exchange	3.80	3.80	3.80	3.80
Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
Border price at Market rate (p/mt)	231.80	231.80	231.80	231.80
Border price at Shadow rate (p/mt)	231.80	231.80	231.80	231.80
POLICIES				
Producer Subsidy Equivalent (%)	10.00	10.00	10.00	10.00
Consumer Subsidy Equivalent (%)	-10.00	-10.00	-10.00	-10.00
PRICES (pesos/mt)				
Producer Price	254.98	254.98	254.98	254.98
Consumer price	254.98	254.98	254.98	254.98
Producer price change	23.18	23.18	23.18	23.18
Consumer price change	23.18	23.18	23.18	23.18
QUANTITY EFFECTS ('000 mt)				
Change in production	1.54	1.32	1.10	0.88
Change in consumption	-2.10	-2.10	-2.10	-2.10
New production level	23.54	23.32	23.10	22.88
New consumption level	32.90	32.90	32.90	32.90
Net imports	9.36	9.58	9.80	10.02
Change in net imports	-3.64	-3.42	-3.20	-2.98
FINANCIAL IMPLICATIONS ('000 pesos)				
Change in producer receipts	902.63	846.53	790.44	734.34
Change in consumer expenditures	275.84	275.84	275.84	275.84
Change in Forex. costs (savings)	-843.75	-792.76	-741.76	-690.76
Budget costs (revenues)	-216.96	-222.06	-227.16	-232.26
WELFARE EFFECTS ('000 pesos)				
Producer gain (loss)	527.81	525.26	522.71	520.16
Consumer gain (loss)	-786.96	-786.96	-786.96	-786.96
Efficiency loss in production	17.85	15.30	12.75	10.20
Efficiency loss in consumption	24.34	24.34	24.34	24.34
Total deadweight loss	42.19	39.64	37.09	34.54
CHECK	0.00	0.00	0.00	0.00

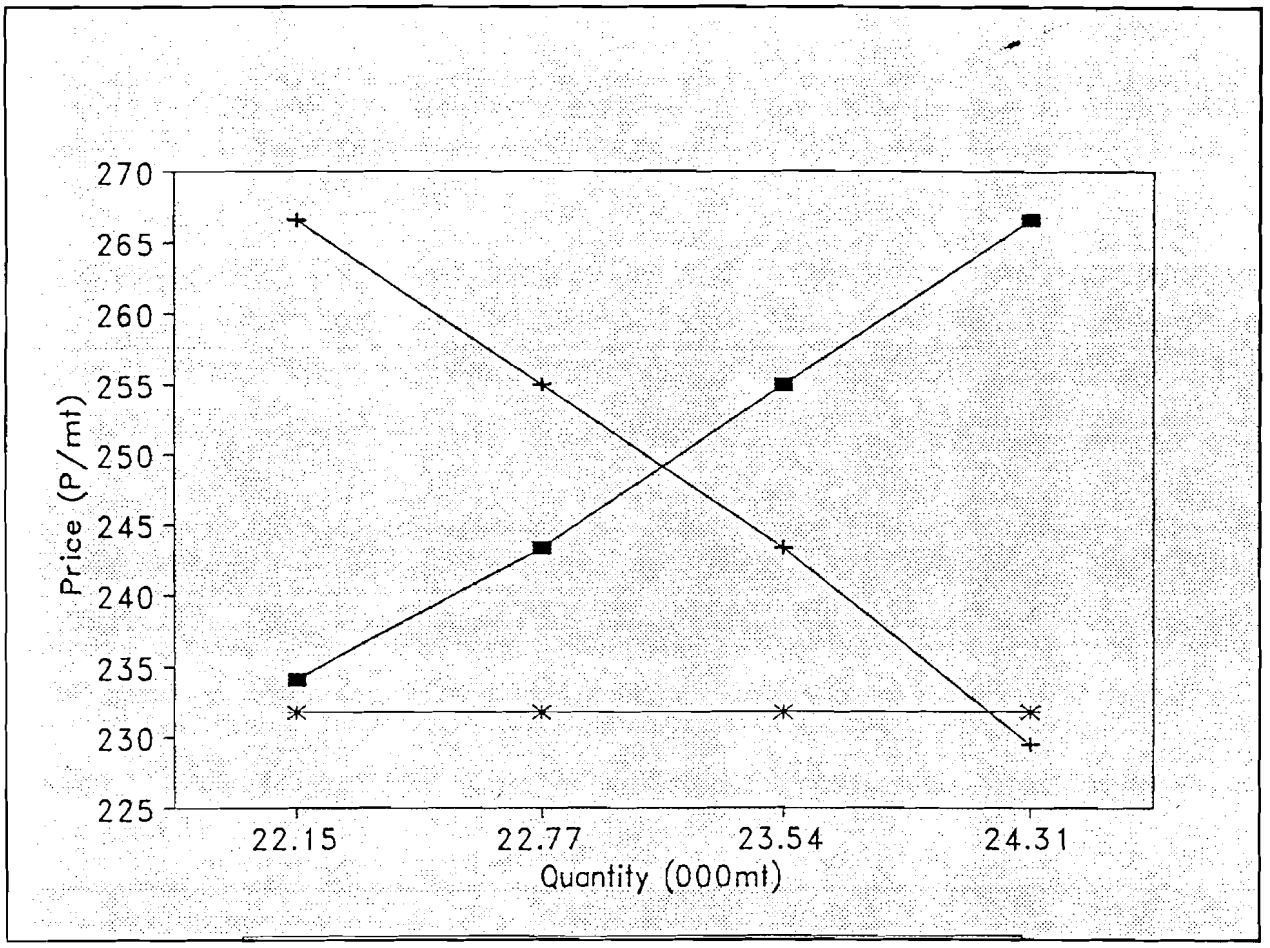


Figure 2.5: Market Diagram

To plot the results, use the Lotus graph option and select a line graph. Note that the X axis of this graph is quantity. The correct quantity to use for the X axis is the "New Production Level." Then select the "Producer Price", "Consumer Price" and the "Border Price" series for lines A, B and C. Be sure to give a title to the graph and label both axes. When viewed, the final graph should look like the one shown in Figure 2.5. What is the autarky equilibrium in the rice market?

BEST AVAILABLE COPY

Table 2.3: Tariff Height and Economic Cost

Exercise 2.3 Tariff Height and Economic Cost	Tariff Policy	Tariff Policy	Tariff Policy	Tariff Policy
ASSUMPTIONS AND DATA				
Supply elasticity	0.70	0.70	0.70	0.70
Demand elasticity	-0.60	-0.60	-0.60	-0.60
Initial Production ('000 mt)	22.00	22.00	22.00	22.00
Initial Consumption ('000 mt)	35.00	35.00	35.00	35.00
Initial net imports ('000 mt)	13.00	13.00	13.00	13.00
World price ($US/mt)	55.00	55.00	55.00	55.00
Exchange rate (P/$US)	3.80	3.80	3.80	3.80
Foreign exchange premium (%)	0.00	0.00	0.00	0.00
Shadow price of foreign exchange	3.80	3.80	3.80	3.80
Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
Border price at Market rate (p/mt)	231.80	231.80	231.80	231.80
Border price at Shadow rate (p/mt)	231.80	231.80	231.80	231.80
POLICIES				
Producer Subsidy Equivalent (%)	10.00	15.00	20.00	25.00
Consumer Subsidy Equivalent (%)	-10.00	-15.00	-20.00	-25.00
PRICES (pesos/mt)				
Producer Price	254.98	266.57	278.16	289.75
Consumer price	254.98	266.57	278.16	289.75
Producer price change	23.18	34.77	46.36	57.95
Consumer price change	23.18	34.77	46.36	57.95
QUANTITY EFFECTS ('000 mt)				
Change in production	1.54	2.31	3.08	3.85
Change in consumption	-2.10	-3.15	-4.20	-5.25
New production level	23.54	24.31	25.08	25.85
New consumption level	32.90	31.85	30.80	29.75
Net imports	9.36	7.54	5.72	3.90
Change in net imports	-3.64	-5.46	-7.28	-9.10
FINANCIAL IMPLICATIONS ('000 pesos)				
Change in producer receipts	902.63	1380.72	1876.65	2390.44
Change in consumer expenditures	275.84	377.25	454.33	507.06
Change in Forex. costs (savings)	-843.75	-1265.63	-1687.50	-2109.38
Budget costs (revenues)	-216.96	-262.17	-265.18	-226.01
WELFARE EFFECTS ('000 pesos)				
Producer gain (loss)	527.81	805.10	1091.31	1386.45
Consumer gain (loss)	-786.96	-1162.19	-1525.24	-1876.13
Efficiency loss in production	17.85	40.16	71.39	111.55
Efficiency loss in consumption	24.34	54.76	97.36	152.12
Total deadweight loss	42.19	94.92	168.75	263.67
CHECK	0.00	0.00	0.00	0.00

Table 2.4: Tracing Supply and Demand Curves

Exercise 2.4 Tracing Supply and Demand Curves	Combined Policy	Combined Policy	Combined Policy	Combined Policy
ASSUMPTIONS AND DATA				
Supply elasticity	0.70	0.70	0.70	0.70
Demand elasticity	-0.60	-0.60	-0.60	-0.60
Initial Production ('000 mt)	22.00	22.00	22.00	22.00
Initial Consumption ('000 mt)	35.00	35.00	35.00	35.00
Initial net imports ('000 mt)	13.00	13.00	13.00	13.00
World price ($US/mt)	55.00	55.00	55.00	55.00
Exchange rate (P/$US)	3.80	3.80	3.80	3.80
Foreign exchange premium (%)	0.00	0.00	0.00	0.00
Shadow price of foreign exchange	3.80	3.80	3.80	3.80
Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
Border price at Market rate (p/mt)	231.80	231.80	231.80	231.80
Border price at Shadow rate (p/mt)	231.80	231.80	231.80	231.80
POLICIES				
Producer Subsidy Equivalent (%)	1.00	5.00	10.00	15.00
Consumer Subsidy Equivalent (%)	-15.00	-10.00	-5.00	1.00
PRICES (pesos/mt)				
Producer Price	234.12	243.39	254.98	266.57
Consumer price	266.57	254.98	243.39	229.48
Producer price change	2.32	11.59	23.18	34.77
Consumer price change	34.77	23.18	11.59	-2.32
QUANTITY EFFECTS ('000 mt)				
Change in production	0.15	0.77	1.54	2.31
Change in consumption	-3.15	-2.10	-1.05	0.21
New production level	22.15	22.77	23.54	24.31
New consumption level	31.85	32.90	33.95	35.21
Net imports	9.70	10.13	10.41	10.90
Change in net imports	-3.30	-2.87	-2.59	-2.10
FINANCIAL IMPLICATIONS ('000 pesos)				
Change in producer receipts	87.05	442.39	902.63	1380.72
Change in consumer expenditures	377.25	275.84	150.09	-32.94
Change in Forex. costs (savings)	-765.87	-665.27	-600.36	-486.78
Budget costs (revenues)	-1056.07	-498.72	152.18	926.88
WELFARE EFFECTS ('000 pesos)				
Producer gain (loss)	51.17	259.44	527.81	805.10
Consumer gain (loss)	-1162.19	-786.96	-399.57	81.37
Efficiency loss in production	0.18	4.46	17.85	40.16
Efficiency loss in consumption	54.76	24.34	6.08	0.24
Total deadweight loss	54.94	28.80	23.93	40.40
CHECK	0.00	0.00	0.00	0.00

CHAPTER 3: INTRODUCTION TO MULTI-MARKET MODELING

Chapter 2 focused on market level modeling with a single commodity. By using the concept of a *total elasticity*, it was possible to compute the corresponding changes in quantities that a price policy intervention elicited. This single commodity approach is perfectly valid where no significant *cross price effects* exist. However, cross price effects occur when the supply and/or demand for a particular commodity are affected by the changes in the price of another commodity or the price of an input.

Chapters 3 and 4 extend the single commodity analysis of the previous chapter to explore cases in which significant cross-price effects exist but have not been adequately captured in the own-price elasticity estimates. Such cases occur when the prices of other commodities are held constant in the statistical procedure used to estimate the elasticity. More importantly, they occur when relative agricultural prices have been fixed by the government over a long period of time and therefore statistical procedures cannot estimate the potential cross price effects. Therefore, throughout the discussion of multi-market models, the use of *partial elasticities* is assumed. (Recall from Chapter 1 that a partial elasticity of supply relates a relative change in the quantity supplied to a relative change in its price, *holding the prices of all other commodities constant.*)

The analysis proceeds in stages. In Chapter 3, the related concepts *indirect policy effect* and *feedback effect* are introduced. A single exercise is developed in which an additional commodity, maize, is added to the exercises of the previous chapter. The exercise is limited to the case where both commodity markets clear through quantity adjustments and specifically illustrates an *indirect* policy effect. Analysis of the case where one or more of the commodity markets clear endogenously, (i.e., adjustments of both quantities and prices take place within the domestic market with no government intervention) is reserved for Chapter 4. As will be seen, endogenous prices lead to *feedback* effects.

THE CONCEPT OF MULTI-MARKET EFFECTS

Multi-market effects is the term used to describe both the indirect effects of commodity policy on other markets, and the feedback effects from other markets, Each arises because of the linkages of the commodity being analyzed with other commodities and with factor markets. The basic idea behind multi-market effects is best explained by an example.

Figure 3.1 describes the case in which two commodities, maize and rice, are linked because they are substitutes in both production and consumption. Two commodities are considered to be production (consumption) substitutes when an increase in the production (consumption) of one commodity leads to a reduction in production (consumption) of the other. In Figure 3.1 the markets for rice and maize are in equilibrium and there is no government intervention. World market prices prevail, i.e. producer, consumer and border prices are all the same.

Suppose that the government decides to tax rice producers by setting the producer price of rice (but not the consumer price) below the border price. As Figure 3.1 illustrates, the total effect of

this policy intervention in both markets is the sum of (a) that affecting the rice market directly due to the change in its own price (the "direct" or "own" effect); and, (b) that affecting the maize market through the impact of the price of rice on the supply of maize (the "indirect" or "cross-price" effect). At constant factor prices, the rice price decrease raises the relative profitability of producing maize. Hence, profit maximizing producers, at the margin, shift resources out of the production of rice and into the production of maize. This movement of resources into maize is represented by a rightward shift of the maize supply curve increasing production to S_{m1}.

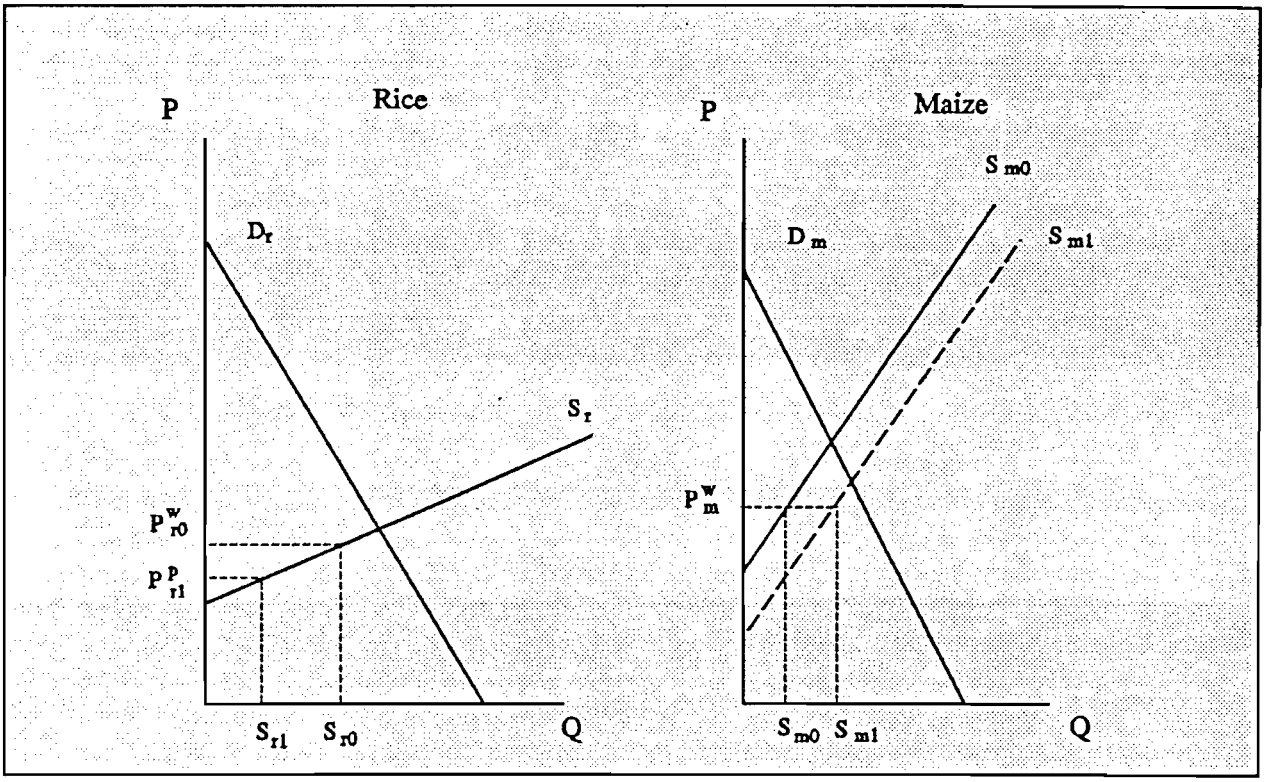


Figure 3.1: Illustration of an Indirect Effect

If the price of maize were allowed to change in response to the shift in its supply curve, a *feedback* process would follow. The increase in the supply of maize would cause a decline in its price. This, in turn, would produce a rightward shift in the rice supply curve. (Chapter 4 will explain this effect in detail.) However, since both commodity prices are exogenous, all feedback effects are eliminated.

BEST AVAILABLE COPY

CALCULATING MULTI-MARKET EFFECTS

The 6 equations (3.1) shown below define the simplest multi-market model when all prices are exogenous.

$$
\begin{aligned}
S_r &= a + bP_r^P + cP_m^P && \textit{Supply of rice} \\
D_r &= d + eP_r^c + fP_m^c && \textit{Demand for rice} \\
S_m &= g + hP_m^P + iP_r^P && \textit{Supply of maize} \\
D_m &= j + kP_m^c + lP_r^c && \textit{Demand for maize} \\
S_r + M_r &= D_r && \textit{Market clearing for rice} \\
S_m + M_m &= D_m && \textit{Market clearing for maize}
\end{aligned}
\qquad (3.1)
$$

where P_r^P is the producer price of rice and P_r^c is the consumer price of rice.

Again, because the interest is in analyzing changes in policy, the constants (intercepts) are unnecessary and the relevant equations for examining the impact of a change in price on quantities supplied and demanded are the slope coefficients multiplied by the percentage change in the exogenous prices.[12]

$$
\begin{aligned}
\Delta S_r &= b\Delta P_r^P + c\Delta P_m^P && \textit{Change in the supply of rice} \\
\Delta D_r &= e\Delta P_r^c + f\Delta P_m^c && \textit{Change in the demand for rice} \\
\Delta S_m &= h\Delta P_m^P + i\Delta P_r^P && \textit{Change in the supply of maize} \\
\Delta D_m &= k\Delta P_m^c + l\Delta P_r^c && \textit{Change in the demand for maize}
\end{aligned}
\qquad (3.2)
$$

Multiplying through by initial or base year quantities and prices and converting to *elasticities* results in equations that are very similar to the single commodity equations except that a *cross price elasticity* term is now included. The cross price elasticity is defined in Equation 3.3

[12] It is not necessary to assume that the supply and demand curves are linear throughout as implied in the previous equations. The crucial assumption is that the portion of the curve in the vicinity of the changes being estimated is linear.

$$\epsilon_{rm} = \frac{\textit{relative change in quantity supplied of rice}}{\textit{corresponding relative change in the producer price of maize}} \quad (3.3)$$

Cross price elasticities relate a proportional change in the quantity of one commodity to a proportional change in the price of a different commodity. Suppose the cross price elasticity of the supply of rice and the price of maize (ϵ_{rm}) is -.1. This indicates that for every 10% increase in the price of maize, the quantity of rice produced will decline by 1%. Commodities whose cross-price elasticities of supply are negative are called *production substitutes*. If the cross price elasticities of supply are positive, the two commodities are called *production complements*.[13]

For the total change in the quantity supplied (demanded) of rice, the incorporation of cross-commodity effects leads to the inclusion of an additional term in the supply (demand) equation that captures how the supply (demand) of rice is affected by a change in the price of maize. The results are shown below for the change in the supply of rice where ϵ_{rr} refers to the partial own price elasticity of supply of rice , i.e., it does not now include the *sum* total of changes in the supply of rice due to a change in its own price since the impact of the change in the price of maize has been excluded.

$$\Delta S_r = \left[\epsilon_{rr} \times S_r \times \frac{\Delta P_r^p}{P_r^p}\right] + \left[\epsilon_{rm} \times S_r \times \frac{\Delta P_m^p}{P_m^p}\right] \quad (3.4)$$

Analogous calculations are required to compute the demand for rice and for the supply and demand for maize. If prices are endogenous, the resulting *feedback* from one commodity to another requires the solution of a set of simultaneous equations. However, when both the price of rice and maize are exogenous, the multi-market model can be solved in the same way as the single commodity model is solved. Each equation is evaluated for the effect of price changes using the equations indicated above and the results are substituted in the market-clearing equations to obtain the net impact on trade.

A PRODUCER TAX

To compute the impact of a producer tax on rice on the supply of maize, begin by copying the Lotus 1-2-3 file containing the work of the previous chapter. (If instructions have been followed, it is called CHAPT2.WK1) Using the DOS copy command, at the command prompt, type: COPY A:CHAPT2.WK1 A:CHAPT3.WK1. Retrieve the CHAPT3 file and make the following modifications.

---

[13] The reverse holds for cross price elasticities of demand, i.e. commodities whose cross price elasticities of demand are positive are called substitutes, etc.

Step 1:

Using Exercise 2.1, (now 3.1) revise the spreadsheet labels as shown in Table 3.1. Add the label rice to the first column and relabel the second column "Maize Impact." Replace the rice data with the appropriate data for maize as shown in the Assumptions and Data block of Table 3.1. (For the moment, ignore the final two columns in this table.) Finally, erase the previous financial and welfare effects calculations including the headings.[14]

Step 2:

Add two rows to the ASSUMPTIONS AND DATA block of the table called "Supply cross elasticity" and "Demand cross elasticity." Place these two rows just below those for the own price elasticities as indicated in Table 3.1. In the supply cross elasticity row, enter -.2 for both crops. Use .1 for the cross price elasticity of demand. (Be sure to insert the rows.) Recall that a positive cross price elasticity of demand indicates that users of maize will consider the price of rice in their consumption decisions. This is particularly true of livestock producers for whom the two commodities are easily substitutable.

Step 3:

Since the government is not adjusting the price of maize, enter the value zero next to the producer and consumer subsidy equivalent headings for maize.

Step 4:

Insert four new rows to the QUANTITY EFFECTS block called "Cross price change in production", "Cross price change in consumption", "Total change in production" and "Total change in consumption." Table 3.1 indicates the appropriate location for these rows and shows the minor changes required to the other subheadings in this block. Compute the impact on rice supply due to a change in the price of maize by entering the following formula into the cross price change in production cell for rice.

$$\Delta S_{rice\ /\ maize} = \epsilon_{rm} \times S_{ro} \times \frac{\Delta P^{P}_{mo}}{P^{P}_{mo}} \qquad (3.5)$$

Using cell addresses, the correct formula is +B6*B9*C25/C17. The formula to calculate the impact of a change in the price of rice on maize supply is analogous.

---

[14] Analyzing the welfare impacts in multi-market exercises with several distortions is conceptually complicated. Therefore it has not been attempted here.

Table 3.1: Producer Policy Intervention: Two-Commodity Market

A	B	C	D	E
1) Exercise 3.1: Two commodity market	Rice	Maize	Rice	Maize
2) Comparison of policy instruments	Prod. tax	Impact	Combined	Impact
3)				
4) ASSUMPTIONS AND DATA				
5) Supply elasticity	0.70	0.70	0.70	0.70
6) Supply cross elasticity	-0.2	-0.2	-0.2	-0.2
7) Demand elasticity	-0.60	-0.60	-0.60	-0.60
8) Demand cross elasticity	0.1	0.1	0.1	0.1
9) Initial Production ('000 mt)	22.00	29.00	22.00	29.00
10) Initial Consumption ('000 mt)	35.00	32.00	35.00	32.00
11) Initial net imports ('000 mt)	13.00	3.00	13.00	3.00
12) World price ($US/mt)	55.00	64.00	55.00	64.00
13) Exchange rate (P/$US)	3.80	3.80	3.80	3.80
14) Foreign exchange premium (%)	0.00	0.00	0.00	0.00
15) Shadow price of foreign exchange	3.80	3.80	3.80	3.80
16) Unloading costs ($US/mt)	6.00	6.00	6.00	6.00
17) Border price at Market rate (p/mt)	231.80	266.00	231.80	266.00
18) Border price at Shadow rate (p/mt)	231.80	266.00	231.80	266.00
19) POLICIES				
20) Producer Subsidy Equivalent (%)	-10.00	0.00	10.00	0.00
21) Consumer Subsidy Equivalent (%)	0.00	0.00	10.00	0.00
22) PRICES (pesos/mt)				
23) Producer Price	208.62	266.00	254.98	266.00
24) Consumer price	231.80	266.00	208.62	266.00
25) Producer price change	-23.18	0.00	23.18	0.00
26) Consumer price change	0.00	0.00	-23.18	0.00
27) QUANTITY EFFECTS ('000 mt)				
28) Direct change in production	-1.54	0.00	1.54	0.00
29) Cross price change in production	0.00	0.58	0.00	-0.58
30) Direct change in consumption	0.00	0.00	2.10	0.00
31) Cross price change in consumption	0.00	0.00	0.00	-0.32
32) Total change in production	-1.54	0.58	1.54	-0.58
33) Total change in consumption	0.00	0.00	2.10	-0.32
34) New production level	20.46	29.58	23.54	28.42
35) New consumption level	35.00	32.00	37.10	31.68
36) Net imports	14.54	2.42	13.56	3.26
37) Change in net imports	1.54	-0.58	0.56	0.26

$$\Delta S_{maize\ /rice} = \varepsilon_{mr} \times S_{mo} \times \frac{\Delta P^{p}_{ro}}{P^{p}_{ro}} \qquad (3.6)$$

Step 5:

Enter the appropriate formulas to calculate the impact of changing maize prices have on the demand for rice. For example, the formula for rice is:

$$\Delta D_{rice} = \eta_{rm} \times D_{ro} \times \frac{\Delta P^{c}_{mo}}{P^{c}_{mo}} \qquad (3.7)$$

Step 6

Add the quantity changes resulting from both the direct and indirect changes to the rows that summarize total changes in quantities produced and consumed. Then edit the formulas that calculate the new level of production and consumption to reflect the additional quantity changes due to the cross price effects. For example, the new rice production level should now be calculated as the initial production level plus the **total** change in production.

Simulating a decrease in rice prices resulting from a producer tax now gives the expected result. Rice output declines as determined by its own supply elasticity. Maize output, on the other hand, increases because it is a production substitute for rice. This exercise demonstrates that in the presence of multi-market effects, a single commodity analysis will fail to capture any impacts on related commodity markets.

Table 3.1 also shows the result of repeating this exercise for the Combined Rice Subsidy exercise. This exercise can be accomplished by copying the first two columns over the original third and fourth column of the worksheet, and then changing the producer and consumer subsidy equivalents for rice to reflect the Combined Policy exercise (i.e., type +10 next to the Producer and Consumer Subsidy Equivalent headings). The correct results are reported immediately. Notice that there is now a decrease in both the production and consumption of maize. Why?

CHAPTER 4: MULTI-MARKET MODELS WITH PRICE ENDOGENEITY [15]

Chapter 4 introduces a new element into multi-market modeling, namely, the presence of a commodity for which the adjustments of quantities and prices are assumed to take place entirely within domestic markets. As previous comments have indicated, this produces a significant change, not only in the characterization of the market, but in the complexity of the computations required to determine the effects of a change on price.

As explained in Chapter 1, once one or more prices are endogenous to the system, the solution of the system to a price policy change in one of the markets cannot be found by the simple substitution of prices in to the commodity demand and supply curves, with the market clearing through changes in net trade. With price endogeneity, the system must be solved as a set of simultaneous equations.

ILLUSTRATING A FEEDBACK EFFECT

Again, market adjustment in the presence of price endogeneity is best illustrated by an example. Figure 4.1 describes the case in which rice and maize are again both production and consumption substitutes. The two markets are initially in equilibrium and there is no government intervention. Producers and consumers in the rice market face an exogenous world price with net imports equal to (D_o - S_o). Maize, however, is assumed to be a nontradable. Equilibrium is achieved in this market at the point (Q_e,P_e) where domestic supply is equal to domestic demand.[16]

Suppose the government decides to impose a tariff that raises the price in the rice market to P_{s1} to both consumers and producers, increasing domestic production to S_1 and decreasing domestic consumption to D_1. As explained in Chapter 3, a rice price policy change causes a series of indirect effects in the maize market. Specifically, a rice price rise increases the profitability of producing rice relative to maize. Hence profit maximizing producers will, at the margin, shift resources out of the production of maize and into the production of rice. This movement of resources out of maize production is represented by a leftward shift in the maize supply curve to S_{m1}.

A similar indirect effect occurs on the demand side. At a higher relative price for rice, consumers will maximize their utility by increasing the consumption of the substitute commodity -

---

[15] Chapters 4-6 are based on an unpublished paper written for the Agricultural Policy Analysis Project by Stefano Pagiola entitled *Notes on the Implementation of Multi-Market Analysis* (Food Research Institute, September, 1989). This paper is in turn based on a series of multi-market models by Braverman and Hammer of the World Bank.

[16] Recall, however, that price endogeneity can also occur with traded commodities; i.e., the "large country" case.

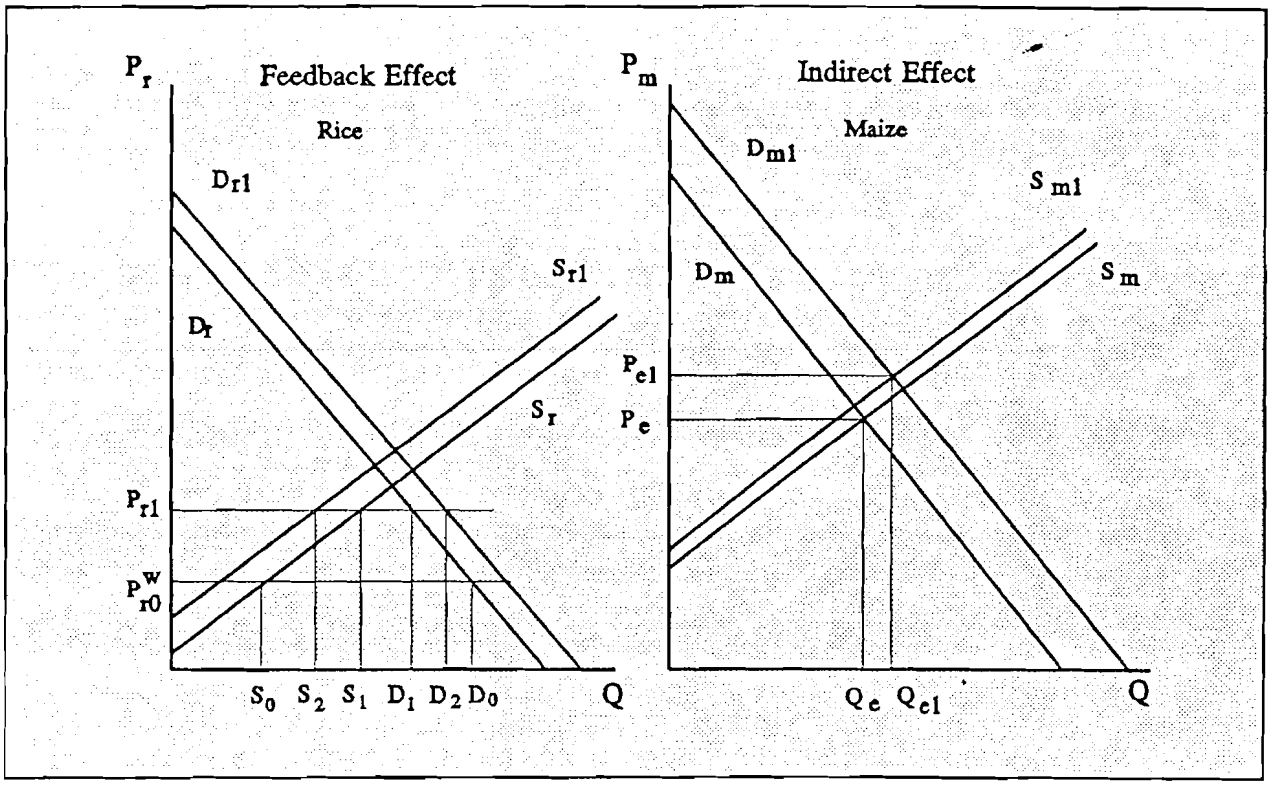


Figure 4.1: Illustration of an Indirect and Feedback Effect

maize.[17] The increase in the consumption of maize is illustrated by a rightward shift in the maize demand curve to D_{m1}.

Yet, unlike the example in Chapter 3, the quantity changes in maize are not reflected in a change in net trade, but rather the market equilibrates through price adjustment. The shifts in the maize demand and supply curves induce an increase in the price of maize, and an increase *or* decrease in the quantities demanded and supplied. (The direction of the change in quantities depends on the slopes of the supply and demand curves - the own price elasticities, and the magnitude of the shifts in the curves - the cross-price elasticities.)

The increase in the maize price, in turn, sets in motion a *feedback* effect on the rice market. The new higher price of maize increases the relative profitability of producing maize and

[17] Review the discussion in Chapter 1 (pp. 6-8) regarding the derivation of consumer demand if this idea is not clear.

BEST AVAILABLE COPY

consequently, producers will shift back into maize production and away from rice.[18] This feedback effect is represented by a leftward shift in the rice supply curve from S_s to S_{s1}, decreasing supply to S_2. Because the two commodities are also consumption substitutes, a similar feedback effect occurs in the consumption side, represented in Figure 4.1 by a rightward shift in the rice demand curve from D_s to D_{s1}, increasing consumption to D_2. This process continues until both markets reach a new equilibrium.

From this discussion it should now be clear that the key difference between an indirect effect and a feedback effect is that the former occurs in the market for the alternative commodity, and latter occurs in the original commodity market facing the exogenous price change. Both effects, however, result from the cross price linkages between the two commodities.

MATHEMATICAL REPRESENTATION OF A MULTI-MARKET MODEL

To illustrate these ideas mathematically, consider the familiar set of commodity equations derived in 3.1-3.2. They are reproduced in Equation 4.1 with one exception: the possibility for trade adjustment has been removed from the market clearing equation for maize. Imports and exports are not a way in which the maize market can adjust to changes in either price or quantity.[19]

$$
\begin{aligned}
S_r &= a + bP_r^p + cP_m^p && \textit{Supply of rice} \\
D_r &= d + eP_r^c + fP_m^c && \textit{Demand for rice} \\
S_m &= g + hP_m^p + iP_r^p && \textit{Supply of maize} \\
D_m &= j + kP_m^c + lP_r^c && \textit{Demand for maize} \\
S_r + M_r &= D_r && \textit{Market clearing for rice} \\
S_m &= D_m && \textit{Market clearing for maize}
\end{aligned}
\qquad (4.1)
$$

Using the difference quotient notation, the relevant equations for examining the impact of a change in the price of rice are:

where ΔS_{rr} denotes the ΔS_r due to a change in P_r, ΔS_{rm} is the ΔS_r due to a change in P_m, etc.

---

[18] The magnitude of a single feedback effect will be always less than the magnitude of the original direct effect that brought it about; otherwise the system will never reach a new equilibrium.

[19] See also footnote 12, Chapter 3.

$$\begin{aligned} \Delta S_{rr} + \Delta S_{rm} + \Delta M_r &= \Delta D_{rr} + \Delta D_{rm} && \textit{Market clearing for rice} \\ \Delta S_{mm} + \Delta S_{mr} &= \Delta D_{mm} + \Delta D_{mr} && \textit{Market clearing for maize} \end{aligned} \tag{4.2}$$

Equation 4.3 shows the equilibrium conditions in the *change* form of the supply and demand schedules for rice.[20] Note that the change form for each element of a market-clearing condition is *always* comprised of three elements: 1) the elasticity for the initial quantity and price variables; 2) the initial quantity corresponding to the element in the market-clearing condition; and 3) a relative change in an exogenous or endogenous price variable. The first equation in brackets is equal to ΔS_{rr}, the second element is equal to ΔS_{rm} and so on.

$$\left[\epsilon_{rr} \times S_{ro} \times \frac{\Delta P_{ro}}{P_{ro}}\right] + \left[\epsilon_{rm} \times S_{ro} \times \frac{\Delta P_{mo}}{P_{mo}}\right] + M_{ro} \times \frac{\Delta M_{ro}}{M_{ro}} = \left[\eta_{rr} \times D_{ro} \times \frac{\Delta P_{ro}}{P_{ro}}\right] + \left[\eta_{rm} \times D_{ro} \times \frac{\Delta P_{mo}}{P_{mo}}\right] \tag{4.3}$$

Rearranging (4.3) so that the endogenous variables P_m and M_r (and the terms related to them) are on the left, and the exogenous variable P_r and its terms is on the right gives:

$$(S_{ro}\,\epsilon_{rm} - D_{ro}\,\eta_{rm})\frac{\Delta P_{mo}}{P_{mo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}} = (D_{ro}\,\eta_{rr} - S_{ro}\,\epsilon_{rr})\frac{\Delta P_{ro}}{P_{ro}} \tag{4.4}$$

The market equilibrium equation for maize (Equation 4.5) is slightly different from rice. As noted above, it has been defined as a nontradable and hence it does not include the variable M, net imports. Arranging the equation so that the exogenous variables are on the right and endogenous variables on the left gives:

---

[20] Equation 4.3 is derived by totally differentiating the market-clearing condition for rice and converting the result to elasticities. See Pagiola, op. cit., p. 4, for an example of how this is done. Knowledge of calculus is not required to complete the exercises in this volume.

$$(S_{mo}\,\epsilon_{mm} - D_{mo}\,\eta_{mm})\frac{\Delta P_{mo}}{P_{mo}} = (D_{mo}\,\eta_{mr} - S_{mo}\,\epsilon_{mr})\frac{\Delta P_{ro}}{P_{ro}} \qquad (4.5)$$

To solve this simultaneous equation system, arrange equations 4.4 and 4.5 in matrix form as follows:

$$\begin{bmatrix} (S_{ro}\,\epsilon_{rm} - D_{ro}\,\eta_{rm}) & M_{ro} \\ (S_{mo}\,\epsilon_{mm} - D_{mo}\,\eta_{mm}) & 0 \end{bmatrix} \begin{bmatrix} \Delta P_{mo}/P_{mo} \\ \Delta M_{ro}/M_{ro} \end{bmatrix} = \begin{bmatrix} (D_{ro}\eta_{rr} - S_{ro}\epsilon_{rr}) \\ (D_{mo}\,\eta_{mr} - S_{mo}\,\epsilon_{mr}) \end{bmatrix} \frac{\Delta P_{ro}}{P_{ro}} \qquad (4.6)$$

The next step is to solve this set of equations for the unknowns, $\Delta M_{ro}/M_{ro}$ and $\Delta P_{mo}/P_{mo}$. The solution method takes advantage of the ability of all spreadsheets to invert and multiply matrices. The next section provides a step-by-step example using Lotus 1-2-3.

SOLVING SIMULTANEOUS EQUATIONS BY MATRIX INVERSION

The use of the matrix inversion capabilities of spreadsheet programs is illustrated below using a simple example. The problem is to find the values of x and y that are a solution to the following equations:

$$\begin{aligned} 2x + 3y &= 31 \\ x + 2y &= 19 \end{aligned} \qquad (4.7)$$

Step 1:

Open a *new* spreadsheet and call it CHAPT4.WK1. Write the equations in matrix form in the upper left had corner of this new spreadsheet. This is done by separating the coefficients from the variables and writing them as a matrix product. The product of the *coefficient* (G) matrix times the *variable* matrix is equal to the matrix (U) of exogenous *constants*.

$$\begin{bmatrix} 2 & 3 \\ 1 & 2 \end{bmatrix} \times \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 31 \\ 19 \end{bmatrix} \qquad (4.8)$$

The Lotus screen showing the coefficient matrix is shown in Table 4.1. Type in the coefficient matrix on the spreadsheet.

Table 4.1: Matrix Inversion Using Lotus 1-2-3

	A	B	C	D
1)	Simultaneous Equation Solution			
2)	----------			
3)	Coef. Matrix (G):		2	3
4)			1	2
5)				
7)	Constants Matrix (U):			31
8)				19
9)	Inverse (G) Matrix:			
10)			2	-3
11)			-1	2
12)	Solution Matrix:			
13)				5
14)				7

Step 2:

Invert the coefficient matrix.

1. Select /Data Matrix Invert
2. Specify the range of the coefficient matrix
3. Specify the output range, i.e., the range in which you want Lotus to put the output. In Table 4.1, this is the range shown next to the "Inverse (G) Matrix".

Step 3:

Once the inverse of the G matrix has been obtained, it remains only to multiply the inverse by the vector of exogenous constants to obtain the values of x and y that are solutions to the two equations given earlier. To multiply matrices in Lotus:

1. Select /Data Matrix Multiply
2. Specify the first range to be multiplied. The first range is the inverse G matrix.
3. Specify the second range to be multiplied. The second range is the "Constants" U vector .
4. Specify the output range (the range where 1-2-3 is to enter the results of the multiplication). In this problem, the range is the "Solution Matrix" block. The solution can be checked by inserting the values of the solution matrix in Equations 4.7.

This simple three step process will be used to solve the multi-market problem described earlier.

SOLVING THE MULTI-MARKET PROBLEM

The exercises in this section continue with the analysis of rice and maize. The only new assumption is that maize is now considered a nontradable.

Step 1:

Set up a new worksheet identical to the one shown in Table 4.2. (Be sure that the position of

the worksheet is as shown in Table 4.2; otherwise the cell addresses of the formulas given below will not correspond to the worksheet.) The data are the initial quantities, prices and elasticities. Enter these data directly.

Table 4.2: Basic Two-Commodity Multi-Market Model

	F	G	H	I	J	K
16)	Basic Two-Commodity Multi-Market Model					
17)	==========	==========	==========	==========	==========	==========
18)	INITIAL QUANTITIES:			ELASTICITIES:		
19)	Commodity:	Rice	Maize		Rice	Maize
20)	Supply	22	29	Supply		
21)	Demand	35	29	Pr	0.74615	-0.2
22)	Imports	13	0	Pm	-0.2	0.7
23)						
24)	INITIAL PRICES:			Demand		
25)		Rice	Maize	Pr	-0.62308	0.1
26)	Domestic	231.80	266.00	Pm	0.1	-0.6
27)	Border	231.80	266.00			
28)						
29)	MATRICES:					
30)	G Matrix			U Matrix		Inverse G Matrix
31)	-7.9	13		-38.2	0.00	0.03
32)	37.7	0		8.7	0.08	0.02
33)						
34)	Solution Matrix					
35)	0.23					
36)	-2.80					
37)						
38)	POLICY CHANGE:	% Change in Exogenous Variables				
39)						
40)	Pr	10.00				
41)						
42)	OUTCOME:					
43)	% Change in Endogenous Variables			New Levels of Endogenous Variables		
44)	Pm	2.31		Pm	272.14	
45)	Sr	7.00		Sr	23.54	
46)	Sm	-0.38		Sm	28.89	
47)	Dr	-6.00		Dr	32.90	
48)	Dm	-0.38		Dm	28.89	
49)	Mr	-28.00		Mr	9.36	

Step 2:

Produce the matrices of coefficients and constants with formulas which use the cell addresses of the initial data. The coefficient matrix is the "G" matrix. It consists of the coefficients of the variables associated with the left hand side of the matrix equation 4.6. Table 4.3 gives the elements of the matrix and the cell addresses from which they were derived. (The cell addresses shown in Table 4.3 may differ significantly if the worksheet has not been organized identically to the one shown in Table 4.2.) The construction of the exogenous constants matrix U is shown in Table 4.4.

Table 4.3: The Coefficient Matrix

G Matrix			
Elements:		Formulas:	
-7.9	13	(G20*J22)-(G21*J26)	G22
37.7	0	(H20*K22)-(H21*K26)	0

Step 3:

Invert the G matrix and display the output in the area below the Inverse G Matrix subheading.

Step 4:

Multiply Inverse G times U to obtain the percentage changes in P_m and M_r that are consistent with a given percentage change in P_r. The result should be placed below the Solution Matrix subheading. Table 4.5 explains that the first element of the solution matrix is the % change in P_m divided by the % change in P_r and the second element is the % change in M_r divided by the % change in P_r.

Table 4.4: Constants Matrix

U Matrix	
Elements:	Formulas:
-38.2	(G21*J25)-(G20*J21)
8.7	(H21*K25)-(H20*K21)

Step 5:

The policy under consideration is a 10% tariff on the price of rice to both consumers and producers. Type in 10 below the POLICY CHANGE heading.

Table 4.5: Solution Matrix

Solution Matrix:	
Elements:	Definition
0.23	$\%\Delta P_m$ / $\%\Delta P_r$
-2.80	$\%\Delta M_s$ / $\%\Delta P_r$

Step 6:

Under the OUTCOME heading, create the appropriate formulas in the "% Change in Endogenous Variables" portion of the table to relate the percentage change in P_{ro} to the endogenous variables. An explanation of some of the calculations is given below and the necessary formulas to make these calculations are given in Table 4.6.

1. The formula for the percentage change in P_{mo} is the first element in the Solution matrix times the percentage change in P_{ro}.

$$\frac{\Delta S_{ro}}{S_{ro}} = \left[\varepsilon_{rr} \times \frac{\Delta P_{ro}}{P_{ro}}\right] + \left[\varepsilon_{rm} \times \frac{\Delta P_{mo}}{P_{mo}}\right] \qquad (4.9)$$

2. The formula for the percentage change in S_{ro} is given by Equation 4.9 shown below. This equation is nothing more than the first two elements of equation 4.3 divided by S_{ro} so that the result calculates percentage changes. Equation 4.9 states that the percentage change in S_{ro} is equal to the own partial price elasticity of supply of rice times the percentage change in P_{ro}, plus the cross price elasticity of the supply of rice with respect to the price of maize times the percentage change in P_{mo}. The percentage change in the other supply and demand variables is derived in exactly the same way.

Table 4.6: Calculating Policy Effects

EFFECTS:	% Change in Endogenous Variables	
Pm	2.31	+F35*G40
Sr	7.00	(J21*G40) + (J22*G44)
Sm	-0.38	(K22*G44) + (K21*G40)
Dr	-6.00	(J25*G40) + (J26*G44)
Dm	-0.38	(K26*G44) + (K25*G40)
Mr	-28.00	+F36*G40

3. The value for the percentage change in net imports is computed by multiplying the second element of the Solution matrix times the percentage change in P_{ro}.

Step 7:

The final step that completes the multi-market solution is to update all of the original initial variables to reflect the changes that have occured. This computation is exactly like the computation done for the single commodity case when the values of the initial conditions are multiplied by (1 + (percentage change/100)) to arrive at the new levels for the endogenous variables. Once these steps have been completed, the worksheet should now contain the results found in Table 4.2.

ANALYZING THE RESULTS

The exercise just completed is similar to the tariff policy intervention exercise performed in Chapter 2 since the quantity changes in the rice market are identical in both cases. (Compare the results of Table 4.2 with the last column of Table 2.1.) This may appear paradoxical given that the above exercise now includes maize. Yet, in this case, both the the single and multi-market models return the same results precisely because the single commodity exercise in Chapter 2 employs *total* price elasticities of supply and demand for rice which, by construction, already capture the feedback effects from the maize market.

To see this more clearly, consider equation 4.10 which is Equation 4.9 after dividing by the percentage change in P_{ro}. The term on the left hand side of the equation *is* the total price elasticity of supply of rice. Equation 4.10 says that this total elasticity is equal to the partial price elasticity of supply of rice plus a term incorporating the cross price elasticity of supply between rice and maize and the relative percentage change in the two prices. Of course, if P_m is held constant (i.e. is equal to zero in the equation), then the total supply elasticity is equal to the own partial elasticity. Likewise, if there are no cross price interactions between maize and rice, the total elasticity will again be equal to the partial elasticity.

$$\frac{\dfrac{\Delta S_{ro}}{S_{ro}}}{\dfrac{\Delta P_{ro}}{P_{ro}}} = \varepsilon_{rr} + \left[\varepsilon_{rm} \times \frac{\dfrac{\Delta P_{mo}}{P_{mo}}}{\dfrac{\Delta P_{ro}}{P_{ro}}} \right] \qquad (4.10)$$

The total price elasticities of supply and demand for rice used in Chapter 2 were derived using Equation 4.10 Hence, the use of a single total elasticity in a one commodity exercise is equivalent to the joint use of the partial and cross price elasticities in a multi-market exercise. By construction, the total elasticities aggregate the information contained in the set of own and cross price elasticities. The only additional information obtained from a multi-market model is the impact of changes in the rice market on the supply, demand and price of maize. The importance of this additional information should not be overlooked. Decision-makers are likely to be equally interested in the multi-market effects of commodity policy, especially if the linked markets are basic staple

crops or important foreign exchange earners.

Suppose only the partial own price elasticities of supply and demand for rice are available. This problem occurs frequently due to the fact that many governments have traditionally intervened in agricultural markets to hold relative prices constant. If so, then reliable statistically estimated cross price elasticity estimates will not be available.[21] A good example is Mexican maize and rice policy. Out of a concern for food security, the Mexican government has traditionally held the relative price between maize (the country's main food staple) and sorghum (used exclusively as a feedgrain) roughly constant to balance production and therefore imports of the two commodities.

The magnitude of the error in using only the partial own-price supply and demand elasticities can be seen by returning to the basic two commodity model developed above. Set all cross price elasticities to zero and repeat the matrix inversion and multiplication steps.[22] Comparison of these results with those which include the cross price elasticities demonstrates the following: if two commodities are production and consumption substitutes, then failure to incorporate multi-market effects will lead to an *overestimation* of the impact a price increase has on the quantities produced of the commodity under analysis, and an underestimation of the quantities consumed. The degree of bias depends, of course, on the size of the own and cross price elasticities.

GENERATING MULTIPLE SOLUTIONS

One form of sensitivity analysis is to vary P_r. Varying the percentage change in the exogenous variable does not require reinverting the matrix because an exogenous parameter is not a matrix element. It is therefore possible to display multiple solutions generated by different values of this parameter. This is achieved through the use of absolute cell addresses.

To proceed, first *reset the cross price elasticities to their original values and repeat the matrix inversion routine*. Then copy the exercise just completed down and to the right of itself. Using the Range/Name/Create command, name this new model "Multiple". Then change the name of the table to "Multiple Solutions to the Basic Two Commodity Multi-Market Model" as shown in Table 4.7.

Recall the series of formulas used to calculate the *percentage changes* in the endogenous variables resulting from the exogenous price change. Each of these formulas references initial data, the parameter being changed, P_{ro}, and the endogenous price parameter, P_{mo}. Return to the first of these formulas in the multi-market exercise and press the F2 *edit* key. Then use the F4 key to change all the cell addresses which reference *initial data* from relative addresses to absolute addresses. For example, the modified formula to calculate the percentage change in P_{mo} should be

---

[21] In this case, the only way to generate cross price elasticity estimates is via mathematical programming models similar to those developed in Volume III of this series.

[22] See the section on Lotus macros and sensitivity analysis on how to automate the matrix inversion routine.

Table 4.7: Generating Multiple Solutions

	N	O	P	Q	R	S
54)	Multiple Solutions to the Basic Two Commodity Multi-Market Model					
55)	==========					
56)	INITIAL QUANTITIES:				ELASTICITIES:	
57)	Commodity:	Rice	Maize		Rice	Maize
58)	Supply	22	29	Supply		
59)	Demand	35	29	Pr	0.74615	-0.2
60)	Imports	13	0	Pm	-0.2	0.7
61)						
62)	INITIAL PRICES:			Demand		
63)		Rice	Maize	Pr	-0.62308	0.1
64)	Domestic	231.80	266.00	Pm	0.1	-0.6
65)	Border	231.80	266.00			
66)						
67)	MATRICES:					
68)	G Matrix			U Matrix	Inverse G Matrix	
69)	-7.9	13		-38.2	0.00	0.03
70)	37.7	0		8.7	0.08	0.02
71)						
72)	Solution Matrix					
73)	0.23					
74)	-2.80					
75)						
76)	POLICY CHANGE:	% Change in Exogenous Variables				
77)						
78)	Pr	10.00	8.00			
79)						
80)	OUTCOME:					
81)	% Change in Endogenous Variables			New Levels of Endogeneous Variables		
82)						
83)	Pm	2.31	1.85	Pm	272.14	270.91
84)	Sr	7.00	5.60	Sr	23.54	23.23
85)	Sm	-0.38	-0.31	Sm	28.89	28.91
86)	Dr	-6.00	-4.80	Dr	32.90	33.32
87)	Dm	-0.38	-0.31	Dm	28.89	28.91
88)	Mr	-28.00	-22.40	Mr	9.36	10.09

+$N$73*078. The percentage change in S_{ro} should now be ($R$59*078)+($R$60*083). Note that both of the prices remain relative cell addresses. Continue with this process for the remaining

formulas in the section. Then repeat the process in the following section which calculates the *new levels* of the endogenous variables by making all of the *initial* prices and quantities absolute addresses.

Return to the section indicating the percentage change in the exogenous variables. Type in a different value for this parameter next to the original. (The value 8 is used in Table 4.7.) Then copy all of the modified formulas under the "% change" and "new level" subheadings to the column directly to the right. The new formulas will automatically make the correct calculations. The worksheet should now be identical to the one shown in Table 4.7.

LOTUS MACROS AND SENSITIVITY ANALYSIS

As noted earlier, once any of the original quantity and elasticity assumptions are changed, the coefficient matrix must be reinverted. In some spreadsheets, notably Microsoft's *Excel*, the invert command is a function and hence any time new data are entered, the matrix is reinverted automatically. However, in spreadsheets such as Lotus 1-2-3 (all versions), Quattro Pro and Supercalc, this computation cannot be automated except by creating a macro which can be run after the data are changed to produce the new solution. Because all other values have been created by formulas, the values for the percentage changes in endogenous variables and the new levels of endogenous variables will be calculated automatically.

A macro is a group of cells constaining a series of Lotus commands. The commands recorded in these cells are performed by Lotus whenever the macro is invoked by pressing the Alt key and a one-letter name assigned to the macro. With a macro, repetitive tasks that would otherwise require several keystrokes can be performed by pressing a simple two-key combination.

Creating an "Invert/Multiply" Macro

A macro that automates the matrix inversion and multiplication routine in the multi-market exercise is shown in Table 4.8. To create this macro, move the cursor to an empty cell to the right of the Multiple Solution exercise just completed. Type in the entire contents of Table 4.8. The "Invert Matrix Macro" heading is a descriptor of the macro to be written. \I is the macro identifier and the one letter name assigned to the macro.

Table 4.8: Matrix Inversion Macro

MACRO DESCRIPTION	KEY	COMMAND
Invert Matrix Macro	'\I	'/DMIN69..O70~ R69..S70~ '/DMMR69..S70~ Q69..Q70~ N73..N74~

The command lines are

merely the sequence of keystrokes one would manually type to invert and multiply the matrices of the multi-market model. Thus the first command line contains the Lotus keystrokes */Data/Matrix /Invert* and then a range identifying the cell addresses of the coefficient matrix in the multi-market model table. The apostrophe keeps the command */Data/Matrix/Invert* from actually being executed as it is entered into the cell. The tilde is a special macro symbol that stands for the *enter* key on the keyboard and should be used in a Macro each time one would have manually pressed the enter key.

The second line is the range identifying the cell addresses where the inverted matrix is to be placed. The third line contains the keystrokes */Data/Matrix/Multiply* and the range of the first matrix to be multiplied. The final two lines indicate the range of the second matrix to be multiplied and the range where the final solution matrix result should be placed.

Once the macro is written, use the /Range/Name/Create command to assign the name "/I" to the first cell of the range where the macro keystrokes are located. To invoke the macro, move the cursor to any empty cell of the worksheet, hold down the Alt key and then press the letter corresponding to the name given the macro.

With a macro, it is now very simple to perform sensitivity analyses on parameters such as elasticities that form part of the G matrix. Return to the "Multiple Solutions" exercise just completed and increase the own price elasticity of supply to 1.2. How do the new results differ from the original?

CHAPTER 5: EXTENDING THE MULTI-MARKET MODEL

Chapter 5 builds on the multi-market model developed in Chapter 4 by demonstrating how the basic framework can be adapted to a variety of situations and policy choices.

The chapter is divided into five sections, the first four illustrating a basic extension to the two commodity model. The exercises are organized in an order of increasing difficulty. The first illustrates how the model can be adapted to explicitly analyze alternative policy instruments such as import quotas. The following two exercises show how to enlarge the model to include additional commodities and to reflect regional differences. A fourth exercise returns to the issue of policy instruments and explains how to incorporate a differential price policy between producers and consumers. The final exercise combines all of the above extensions to form a three commodity, two-region multi-market model with differential taxes.

These exercises illustrate only a few of the extensions that can be made to multi-market models, yet a solid understanding of the above extensions should enable the user to proceed directly to constructing small models reflecting real world situations.[23] The only difficulty lies in writing down the equilibrium market conditions correctly and in such a way that the G and U matrices can be constructed. Before proceeding, the mathematical representation of the basic model in Chapter 4 should be reviewed and understood.

QUANTITATIVE RESTRICTIONS

In the basic model in Chapter 4, the price of rice is considered to be exogenous. Such a formulation is appropriate when a government taxes producers of the commodity and controls imports to meet domestic demand. In other situations, a government may be more directly concerned about the foreign exchange costs of importing, or wish to subsidize producers by restricting imports to a fixed level, allowing the domestic price to increase to equate supply with demand. The appropriate way to model import restrictions is to consider imports the policy variable, and allow prices to vary endogenously.

The basic two commodity model is easily adapted to analyze quantitative restrictions by rearranging the market-clearing condition for rice and entering the new G and U matrices in the appropriate blocks. The new G matrix is then reinverted and multiplied by the new U matrix to provide the final solution matrix. Indeed, this is the basic pattern behind almost every kind of extension to a multi-market model.

Each of the four basic exercises in this chapter begins with the basic model constructed in Chapter 4. For convenience, the market-clearing conditions in the change form of the supply and demand schedules for both commodities are repeated below.

---

[23] Additional extensions are detailed in Pagiola, op. cit., pp.8-13.

$$(S_{ro}\varepsilon_{rm} - D_{ro}\eta_{rm})\frac{\Delta P_{mo}}{P_{mo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}} = (D_{ro}\eta_{rr} - S_{ro}\varepsilon_{rr})\frac{\Delta P_{ro}}{P_{ro}} \quad (5.1)$$

$$(S_{mo}\,\varepsilon_{mm} - D_{mo}\,\eta_{mm})\frac{\Delta P_{mo}}{P_{mo}} = (D_{mo}\eta_{mr} - S_{mo}\,\varepsilon_{mr})\frac{\Delta P_{ro}}{P_{ro}} \quad (5.2)$$

Step 1:

Copy the contents of the file entitled CHAPT4.WK1 to a new file. Call this new file Chapt5.WK1. Copy the basic market model down and to the right of itself. (This will overwrite table 4.7 that displays multiple solutions to the basic model.) Using the Range/Name/Create command, call this new model "Quantity" and change the name of the table to "Quantity Constrained Two Commodity Model"

Step 2:

On a separate piece of paper, write down the market-clearing equation for rice (equation 5.1). Since M_r is now the policy parameter, rearrange this equation so that both price variables (and their related terms) are on the left-hand side, and the import variable M_{ro} and its related terms are on the right-hand side.

Step 3:

Combine this new equation with the market-clearing equation for maize (equation 5.2 rearranged so that P_{ro} is also on the left-hand side) in matrix form. (Refer to Equation 4.6 if this procedure is not clear.) The first element in the G matrix should be the coefficient of$\Delta P_{mo}/P_{mo}$ from the rice market-clearing equation. (This is not necessary in order to solve the model correctly, but by keeping to this order, the remaining instructions will be easier to follow.) Enter the formulas to calculate the elements of both the G and U matrices using the cell addresses of the initial data. If this step has been followed correctly, the formula for the bottom right-hand element of the G matrix should be:

$$S_{mo}\varepsilon_{mr} - D_{mo}\eta_{mr} \quad (5.3)$$

Step 4:

Replace M_r for P_r under the POLICY CHANGE subheading. The policy under consideration is a 28.00% *reduction* in rice imports from 13,000 mt. per year to 9,360 mt. per year. (The

Table 5.1: Quantity Constrained Two-Commodity Model

	N	O	P	Q	R	S
54)	Quantity Constrained Two-Commodity Model					
55)	==========	==========	==========	==========	==========	==========
56)	INITIAL QUANTITIES:				ELASTICITIES:	
57)	Commodity:	Rice	Maize		Rice	Maize
58)	Supply	22	29	Supply		
59)	Demand	35	29	Pr	0.74615	-0.2
60)	Imports	13	0	Pm	-0.2	0.7
61)						
62)	INITIAL PRICES:			Demand		
63)		Rice	Maize	Pr	-0.62308	0.1
64)	Domestic	231.80	266.00	Pm	0.1	-0.6
65)	Border	231.80	266.00			
66)						
67)	MATRICES:					
68)	G Matrix			U Matrix	Inverse G Matrix	
69)	-7.9	38.2		-13.0	0.0063	0.03
70)	37.7	-8.7		0.0	0.0275	0.01
71)						
72)	Solution Matrix					
73)	-0.08					
74)	-0.36					
75)						
76)	POLICY CHANGE: % Change in Exogenous Variables					
77)						
78)	Mr	-28.00				
79)						
80)	OUTCOME:					
81)	% Change in Endogenous Variables			New Levels of Endogeneous Variables		
82)						
83)	Pm	2.31		Pm	272.14	
84)	Pr	10.00		Pr	254.98	
85)	Sr	7.00		Sr	23.54	
86)	Sm	-0.38		Sm	28.89	
87)	Dr	-6.00		Dr	32.90	
88)	Dm	-0.38		Dm	28.89	

percentage change in imports should be typed in directly.)

Step 5:

Insert a row just after P_m under the "% Change" block. Type in P_r. Also type in P_r in the

following block that calculates the new levels of the endogenous variables. Then eliminate M_r from both columns

Step 6:

Enter the appropriate formula to calculate the percentage change in P_{ro}. This formula is the second element of the Solution Matrix multiplied by the percentage change in the exogenous variable. Also enter the formula to calculate the new level of P_r. (Recall that a new level of a variable is always calculated as the initial value multiplied by [1 + (percentage change/100)].) Then modify all remaining formulas under the "% Change" subheading so that each formula references the new location for P_r.

Step 7:

The remaining step is, of course, to reinvert the new G matrix. One way to do so is to return to the macro located near the upper left-hand corner of the spreadsheet. Edit the macro by entering the ranges which reference the matrices in the *current* table. Then simply invoke the macro. Alternatively, the macro can be inverted manually.

If the above steps have been followed correctly, the results should be identical to those calculated in Chapter 4 and listed in Table 4.2. An import quota that reduces rice imports by 28.00%, raises the domestic price of rice by 10%. Because maize and rice are both production and consumption substitutes, the rice price increase induces an increase in the price of maize and a slight decrease in maize consumption and production.

ENLARGING THE TWO-COMMODITY MODEL

Additional Commodities

In most countries, farmers grow several crops on the same type of land, and even during the same season, in order to diversify their risk. On the demand side, empirical analysis has shown that consumers prefer a varied diet and respond rapidly to changes in relative food prices. In short, there are potentially a large number of multi-market interactions in agriculture, the skill of the analyst is to select those interactions thought to be most relevant to the policy change under consideration. Incorporating several livestock markets in an analysis of feedgrain price changes is an example of a case where it might be important to include these additional markets.

The following exercise shows how the two commodity model can be enlarged to incorporate a third commodity, beans. In this exercise, maize and beans are modeled as production complements because they are often intercropped. They are also modeled as consumption complements since they are often consumed together. While rice and beans are substitutes in production, they are neither consumption complements or substitutes since livestock users would not consider the price of beans in formulating their livestock rations.

Step 1:

Copy the *original* two commodity model (not the exercise just completed) down and to the right of the exercise just completed. Using the Range/Name/Create command, name this new model "Three". Then change the name of the table to "Three Commodity Multi-Market Model".

Step 2:

Insert a new column just after the initial quantity data and a new row after the supply elasticities block. Then enter the initial data for beans as shown in Table 5.1. Beans is a nontradable commodity and so, like maize, its price is endogenous to the system.

Step 3:

The market-clearing equation for beans is given in equation 5.4. shown below. Note that P_{ro} does not appear on the demand side since rice and beans are neither consumption complements

$$S_{bo}\varepsilon_{bb}\frac{\Delta P_{bo}}{P_{bo}} + S_{bo}\varepsilon_{bm}\frac{\Delta P_{mo}}{P_{mo}} + S_{bo}\varepsilon_{br}\frac{\Delta P_{ro}}{P_{ro}} = D_{bo}\eta_{bb}\frac{\Delta P_{bo}}{P_{bo}} + D_{bo}\eta_{bm}\frac{\Delta P_{mo}}{P_{mo}} \qquad (5.4)$$

nor substitutes. On a separate piece of paper, arrange this equation so that the endogenous variables and their related terms are on the left-hand side and the exogenous variable, P_{ro} and its related terms, is on the right-hand side, and then collect terms.

Step 4:

A term which incorporates the impact of a change in the price of beans on the supply and demand for maize, and the supply for rice, must be added to the rice and maize market-clearing equations. The new market-clearing equation for rice is given in equation 5.5.

$$\begin{aligned}(S_{ro}\varepsilon_{rm} - D_{ro}\eta_{rm})\frac{\Delta P_{mo}}{P_{mo}} + S_{ro}\varepsilon_{rb}\frac{\Delta P_{bo}}{P_{bo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}} \\ = (D_{ro}\eta_{rr} - S_{ro}\varepsilon_{rr})\frac{\Delta P_{ro}}{P_{ro}}\end{aligned} \qquad (5.5)$$

Write down the market-clearing equation for maize and then add the appropriate cross-price terms for beans to *both* the supply and demand sides, i.e., add $(S_{mo}\epsilon_{mb}\,\Delta P_{bo}/P_{bo})$ to the supply side of the market-clearing equation of maize and $(D_{mo}\eta_{mb}\,\Delta P_{bo}/P_{bo})$ to the demand side. Finally, collect terms

and arrange this equation so that the endogenous variables are on the left-hand side and the exogenous variable, P_{so}, is on the right-hand side.

Table 5.2: Three-Commodity Model

	U	V	W	X	Y	Z	AA	AB	AC
90)	Basic Three-Commodity Multi-Market Model								
91)	==========								
92)	INITIAL QUANTITIES:						ELASTICITIES:		
93)	Commodity:	Rice	Maize	Beans			Rice	Maize	Beans
94)	Supply	22	29	10		Supply			
95)	Demand	35	29	10		Pr	0.746	-0.2	-0.3
96)	Imports	13	0	0		Pm	-0.2	0.7	0.2
97)						Pb	-0.3	0.2	0.4
98)									
99)	INITIAL PRICES:					Demand			
100)		Rice	Maize	Beans		Pr	-0.623	0.1	0
101)	Domestic	231.80	266.00	400		Pm	0.1	-0.6	-0.2
102)	Border	231.80	266.00	400		Pb	0	-0.2	-0.3
103)									
104)	MATRICES:								
105)		G Matrix			U Matrix		Inverse G Matrix		
106)									
107)	-7.9	13	-6.6		-38.22		0.00	0.03	-0.05
108)	37.7	0	11.6		8.70		0.08	0.01	0.07
109)	4	0	7		3.00		0.00	-0.02	0.17
110)	Solution Matrix								
111)	0.12								
112)	-2.68								
113)	0.36								
114)	POLICY CHANGE: % Change in Exogenous Variables								
115)									
116)	Pr	10.00							
117)									
118)	OUTCOME:								
119)	% Change in Endogenous Variables				New Levels of Endogenous Variables				
120)	Pm	1.20			Pm	269.19			
121)	Pb	3.60			Pb	414.40			
122)	Sr	6.14			Sr	23.35			
123)	Sm	-0.44			Sm	28.87			
124)	Dr	-6.11			Dr	32.86			
125)	Dm	-0.44			Dm	28.87			
126)	Mr	-26.85			Mr	9.51			
127)	Sb	-1.32			Sb	9.87			
128)	Db	-1.32			Db	9.87			

Step 5:

Arrange the three market clearing equations in matrix form. The first equation in the G matrix should be rice, the second, maize, and the third, beans. The resulting G matrix is now a (3x3) matrix and the U matrix is a (3x1) matrix. Enter the formulas to calculate the additional elements of the G and U matrices using the cell addresses of the original data. (It may be necessary to insert a new row just below the G matrix to accommodate the additional elements.)

Step 6:

The policy change under consideration remains a 10% increase in the price of rice to both consumers and producers so no changes are required to the POLICY CHANGE block. Move to the "% Change" block of the table and insert three rows, one just below P_m, the other two just below the last entry, M_r. Type P_b in the first blank row, and S_b and D_b in the remaining two new rows for both the "% Change" and "New Levels" blocks. (See Table 5.1.)

Step 7:

Enter the formulas that calculate the percentage changes in P_{bo}, S_{bo} and D_{bo}. For example, the new equation to calculate the percentage change in S_{bo} is given in equation 5.6. Also, P_{bo} is calculated as the third element of the solution matrix times the percentage change in P_{ro}. Then edit the remaining formulas in this block so that they also include the impact of a change in the price of beans.

$$\frac{\Delta S_{bo}}{S_{bo}} = \varepsilon_{bb}\frac{\Delta P_{bo}}{P_{bo}} + \varepsilon_{br}\frac{\Delta P_{ro}}{P_{ro}} + \varepsilon_{bm}\frac{\Delta P_{mo}}{P_{mo}} \qquad (5.6)$$

Step 8:

Enter the formulas to calculate the new levels of P_b, S_b, and D_b. Then edit the remaining formulas as required so that they reference the appropriate initial quantities and percentage change values.

Step 9:

Invert the new G matrix either manually or by editing the Invert Matrix macro. (Do not forget to multiply the inverted matrix by the new U matrix if the G matrix is inverted manually.) The correct answers to this exercise are shown in Table 5.1. (In the absence of answers, the model can be checked by setting all cross-price elasticities between beans and the other two commodities to zero and reinverting the matrix. The result should be identical to the basic model.)

The results indicate that incorporating beans into the model reduces the supply response of rice

to the price change and increases the demand response. As a result, rice imports decline only by 26.85%, rather than 28.0% as calculated in the model without beans. The addition of beans to the model also slightly increases the impact of the rice price increase on the maize market.

These results are due to the complex linkages between the three commodities and their competition for factors of production and consumers preferences. Even a simple three commodity model illustrates that these interactions are often impossible to predict without a formal framework, since they depend on the relative magnitudes of all of the elasticities as well as on their signs. Multi-market analysis provides a framework for estimating these endogenous changes in a consistent manner.

ADDITIONAL REGIONS

Very often, decision-makers are concerned with the regional implications of policy change. Regional distinctions are also important if the commodity is grown under a wide range of agroclimatic conditions and so the response to policy may differ significantly by region. In this case, a sound approach is to divide the country into regions and estimate the impact of changes in policy by region.

The following exercise shows how to adapt a multi-market model to analyze the regional impacts of policy. In the exercise, the country is divided into two regions, both of which produce and consume rice and maize. Thus, there is a supply and demand curve for both commodities in both regions. The total amount supplied and demanded for a particular commodity is the sum of the amount supplied and demanded in each of the regions. The market-clearing equation for rice is therefore $S_r^1 + S_r^2 + M_r = D_r^1 + D_r^2$. Regional demand does not have to equal regional supply either before or after the policy change. In other words, the two regions can trade.

An important assumption of this exercise is that there are no costs associated with transporting a commodity from one region to another. Consequently, there is only one price for each commodity and each region produces, consumes and trades at that price. Figure 5.1 illustrates the market for rice *before* the policy change.

Step 1:

Copy the *original* two commodity model down and to the right of the three commodity model just completed. Using the Range/Name/Create command, name this new table "Regional". Then change the name of the table to "Regional Two Commodity Multi-Market Model".

Step 2:

Insert one new column just after the final column of the table and several new rows to

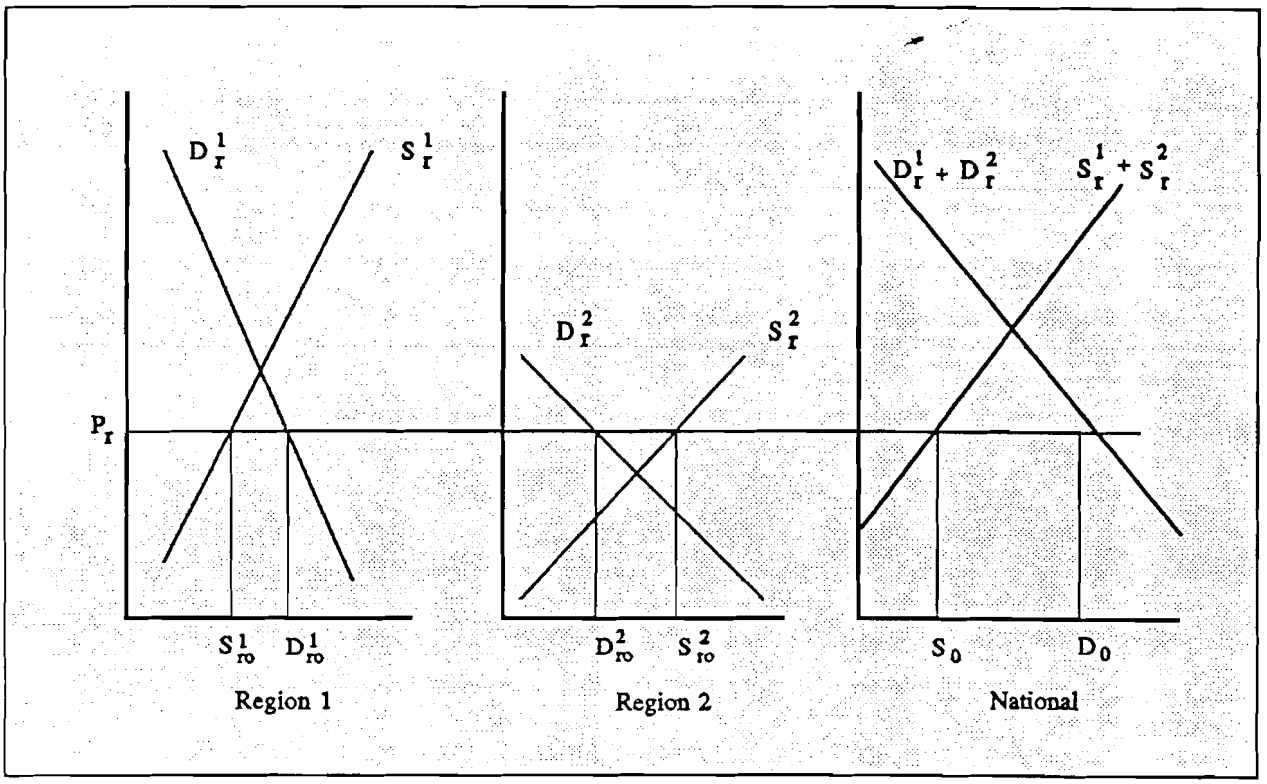


Figure 5.1: Rice Market

accommodate the additional initial data. Enter the new data as shown in Table 5.2.

Step 3:

The new market-clearing equation for rice in the change form of the supply and demand schedules is shown in equation 5.7.

$$\left(S_{ro}^1\varepsilon_{rm}^1 + S_{ro}^2\varepsilon_{rm}^2 - D_{ro}^1\eta_{rm}^1 - D_{ro}^2\eta_{rm}^2\right)\frac{\Delta P_{mo}}{P_{mo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}}$$
$$= \left(D_{ro}^1\eta_{rr}^1 + D_{ro}^2\eta_{rr}^2 - S_{ro}^1\varepsilon_{rr}^1 - S_{ro}^2\varepsilon_{rr}^2\right)\frac{\Delta P_{ro}}{P_{ro}} \qquad (5.7)$$

where ϵ_{rr}^1 refers to the own price elasticity of rice supply in region 1 and ϵ_{rr}^2 is the own price elasticity of supply in region 2. Note that the disaggregation of commodity supply and demand

BEST AVAILABLE COPY

curves by regions expands the formulas for calculating the elements of the G and U matrices, but does not expand the size of the matrices themselves. Write down the new market-clearing equation for maize ($S_m^1 + S_m^2 = D_m^1 + D_m^2$) in the change form of the variables and then rearrange the equation so that the endogenous variables are on the left-hand side, and the exogenous variable, P_r, is on the right-hand side.

If this step has been performed correctly, the new market-clearing equation for maize should be as shown in equation 5.8.

$$\begin{aligned} &\left(S_{mo}^1\varepsilon_{mm}^1 + S_{mo}^2\varepsilon_{mm}^2 - D_{mo}^1\eta_{mm}^1 - D_{mo}^2\eta_{mm}^2\right)\frac{\Delta P_{mo}}{P_{mo}} \\ &= \left(D_{mo}^1\eta_{mr}^1 + D_{mo}^2\eta_{mr}^2 - S_{mo}^1\varepsilon_{mr}^1 - S_{mo}^2\varepsilon_{mr}^2\right)\frac{\Delta P_{ro}}{P_{ro}} \end{aligned} \tag{5.8}$$

Step 4:

Combine the rice and maize market-clearing equations in matrix form. Enter the formulas to calculate the elements of the G and U matrices using the cell addresses of the initial data.

Step 5:

Insert sufficient rows under the "% change" subheading to disaggregate the supply and demand calculations by regions. For example, use the [F2] edit key to add the number 1 next to S_r. Then in a new inserted row below S_r^1, type in S_r^2. Continue this step for the remaining supply and demand entries. (See Table 5.2 if this is not clear.) Then enter the appropriate formulas to calculate the percentage change in the endogenous variables due to the 10.0% tariff on rice. For example, the percentage change in S_r^1 is:

$$\frac{\Delta S_{ro}^1}{S_{ro}^1} = \varepsilon_{rr}^1\frac{\Delta P_{ro}}{P_{ro}} + \varepsilon_{rm}^1\frac{\Delta P_{mo}}{P_{mo}} \tag{5.9}$$

Table 5.3: Two-Commodity Regional Model

	AF	AG	AH	AI	AJ	AK
135)	Two-Commodity Regional Model					
136)	==========	==========	==========	==========	==========	==========
137)	INITIAL QUANTITIES:			ELASTICITIES:		
138)	Commodity:	Rice	Maize		Rice	Maize
139)						
140)	Supply: R1	7	15	Supply: R1		
141)	R2	15	14	Pr	0.74615	-0.2
142)				Pm	-0.2	0.7
143)	Demand: R1	15	11	Supply: R2		
144)	R2	20	18	Pr	0.3	-0.1
145)				Pm	-0.1	0.2
146)						
147)	Imports:	13	0	Demand: R1		
148)				Pr	-0.62308	0.1
149)				Pm	0.1	-0.6
150)	INITIAL PRICES:			Demand: R2		
151)		Rice	Maize	Pr	-0.3	0.2
152)	Domestic	231.80	266.00	Pm	0.2	-0.3
153)	Border	231.80	266.00			
154)						
155)	MATRICES:					
156)	G Matrix		U Matrix		Inverse G Matrix	
157)	-8.4	13	-25.07		0.00	0.040
158)	25.3	0	9.10		0.077	0.026
159)						
160)	Solution Matrix					
161)	0.36					
162)	-1.70					
163)						
164)	POLICY CHANGE:	% Change in Exogenous Variables				
165)						
166)	Pr 10.00					
167)	OUTCOME:					
168)	% Change in Variables		New Variable Level		National Totals	
169)	Pm	3.60	Pm	275.57		
170)	Sr1	6.74	Sr1	7.47	Sr	22.87
171)	Sr2	2.64	Sr2	15.40		
172)	Sm1	0.52	Sm1	15.08	Sm	27.92
173)	Sm2	-0.28	Sm2	13.96		
174)	Dr1	-5.87	Dr1	14.12	Dr	33.66
175)	Dr2	-2.28	Dr2	19.54		
176)	Dm1	-1.16	Dm1	10.87	Dm	29.04
177)	Dm2	0.92	Dm2	18.17		

Step 6:

Repeat the first part of Step 5 for the block that calculates the new levels of the endogenous variables, and then enter the correct formulas for each of the variables.

Step 7:

Insert seven rows at the end of the spreadsheet to calculate the new level of maize and rice supply and demand at the national level. Type the subheading "National Totals" below the last entry in the % change" block. Then enter the appropriate formulas to calculate the new quantities of rice and maize demand and supply at the national level. The first entry is S_r and its formula is simply the sum of S_{ro}^1 and S_{ro}^2.

Step 8:

Invert the new G matrix and multiply this new inverted matrix by the U matrix.

Step 9:

Before analyzing the results, it is crucial to be sure that the model is working properly. One way to do so is to recall that, by construction, the sum of the regional demand and supply for both commodities is equal to national demand and supply, plus imports for rice. If the elasticities of each of the regional curves are identical to the aggregate elasticities used in the basic two commodity one region model, and the sum of the initial quantities supplied and demanded in each region equals the initial quantities used in the basic model, then the results of the regional model will be identical to those of the basic model. The only difference, of course, is that the regional model will disaggregate the quantity changes by region.

To demonstrate this result, change the elasticity estimates for region 2 so that they are identical to the estimates used for region 1. (Region 1's estimates are already the estimates used in Chapter 4.) Then reinvert the matrix (or invoke the matrix inversion macro if it has been edited for this exercise.). If the regional model has been constructed correctly, the new levels of the endogenous variables at the national level should be identical to those calculated in the basic two commodity model. Make the necessary corrections to the table until the model is working correctly, and then re-enter the true elasticities for region 2 and reinvert the matrix. The results should now be those listed in Table 5.2.

An interesting result that emerges from this model is that the impact of a price change on quantities supplied and demanded can vary significantly between regions. In this example, the impact of a price increase in rice induces a larger rice supply *and* demand response in region 1 than in region 2. This is due to the fact that the own price elasticities of supply and demand for rice are smaller (in absolute value) in region 2. In words, the demand and supply for rice are more *inelastic* in region 2.

It is also worth noting the differential regional response of the maize market. In region 1 the quantities consumed and produced increase as a result of the price change in the rice market; yet in region 2, the quantities consumed and produced actually decrease. In the absence of a full-blown mathematical model, it is practically impossible to isolate the most important factor causing this result since the magnitude and sign of several elasticities are involved. The power of the multi-market model is in providing a way to calculate these results simply and rapidly.

COMBINED POLICY INTERVENTION (ADVANCED)

Up to now, the endogenous price multi-market models have only considered situations in which a government raises (or lowers) a price to *both* consumers and producers. Yet, as was demonstrated in the earlier chapters, a price policy, especially for a basic staple crop, may often involve setting a higher price to producers than to consumers.

Incorporating differential prices into the multi-market framework is made possible by defining one price in terms of another. For example, in the following exercise it is assumed that the government wants to subsidize rice producers but also wants consumers to be able to purchase rice at the lower pre-subsidy price. One way to formulate the problem is to define the producer price of rice as: $P^p_r = P^c_r(1 + s)$ where s is the subsidy rate to producers.

Let $(1 + s) = r$. The supply curve of rice in the change form is now:

$$\Delta S_{ro} = S_{ro}\varepsilon_{rr}\frac{\Delta r}{r} + S_{ro}\varepsilon_{rr}\frac{\Delta P^c_{ro}}{P^c_{ro}} + S_{ro}\varepsilon_{rm}\frac{\Delta P_{mo}}{P_{mo}} \qquad (5.10)$$

This equation states that the supply of rice is a function of the price of maize, the consumer price of rice and the subsidy rate the government sets. In short, the government now has two policy variables: the consumer price of rice and the subsidy rate and can induce an increase in the supply of rice either by increasing the consumer price of rice or by increasing the subsidy rate (or both).

Step 1:

Once again, copy the *original* two commodity model down and to the right of the regional model just completed. Using the Range/Name/Create command, name this new table "Dual". Then change the name of the table to "Dual Price Two Commodity Multi-Market Model".

Step 2:

The new policy variable, r, must be included on the supply side of the market-clearing equation of rice as shown in equation 5.11.

$$(S_{ro}\varepsilon_{rm} - D_{ro}\eta_{rm})\frac{\Delta P_{mo}}{P_{mo}} + M_{ro}\frac{\Delta M_{ro}}{M_{ro}} = (D_{ro}\eta_{rr} - S_{ro}\varepsilon_{rr})\frac{\Delta P^{c}_{ro}}{P^{c}_{ro}} - S_{ro}\varepsilon_{rr}\frac{\Delta r}{r} \qquad (5.11)$$

Note that the coefficients on the subsidy rate are the same as those for P_r^c. Why? By construction, the producer price of rice has simply been disaggregated into two components: the consumer price and the subsidy rate, and farmers can be expected to respond in the same way to an increase in either component.

Step 3:

The new policy variable must also be added to the *supply* side of the market-clearing equation for maize. To do this, write down equation 5.2 on a piece of paper and then decompose the price of maize (on the supply side) into its new components. Then collect terms and rearrange the equation so that all endogenous variables are on the left-hand side and all exogenous variables are on the right-hand side. The result is given in Equation 5.12.

$$(S_{mo}\varepsilon_{mm} - D_{mo}\eta_{mm})\frac{\Delta P_{mo}}{P_{mo}} = (D_{mo}\eta_{mr} - S_{mo}\varepsilon_{mr})\frac{\Delta P^{c}_{ro}}{P^{c}_{ro}} - S_{mo}\varepsilon_{mr}\frac{\Delta r}{r} \qquad (5.12)$$

Step 4:

Combine the two market-clearing equations in matrix form. Enter the formulas to calculate the elements of the G and U matrices using the cell addresses of the initial data. (The resulting U matrix should be (2x2).)

Step 5:

Insert a row under the POLICY CHANGE heading and type the letter r. The policy is a 10% subsidy to rice producers. (Be sure to set P_r^c to zero.)

Step 6:

Edit the appropriate formulas under the "% change" subheading to include the additional component of the price of rice, i.e., the subsidy rate, and then invert the G matrix.

To check the results, set r = 0 and P_r^c = to 10%. The outcome should be identical to the basic model developed in Chapter 4. Why?

COMBINING THE EXTENSIONS (ADVANCED)

The final exercise of this chapter combines the last three extensions into a single three commodity, two region differential price market model. Since no instructions will be given, this exercise should not be attempted until the above exercises are fully understood. Nevertheless, by following the same sequence of steps given for the above exercises, the only additional challenge of this exercise will be to correctly specify the G and U matrices. (The most efficient way to proceed is to begin with the completed regional model and then add beans and the differential price policy.)

The data for this exercise are located in Table 5.3. Due to the size of the model, a suggested format is to place the data and assumptions in one table and the subsequent calculations and outcomes in another.

The results of this exercise are reported in Table 5.4. The model can be checked by setting region 2's demand and supply elasticities identical to those in region 1 (which are same estimates used in the three commodity exercise) *and* $r = 0$ and $P_r^c = 10\%$. With these data, a correctly specified model will return the same results as those calculated in the three commodity exercise, the results of which are found in Table 5.1. (Consistency checks to be sure that the model is working properly after changes have been made are highly recommended.)

Table 5.4: Combined Regional and Three Commodity Model

DATA BLOCK (Combined Regional and Three-Commodity Multi-Market Model)

INITIAL QUANTITIES:					ELASTICITIES:				
Commodity:		Rice	Maize	Beans			Rice	Maize	Beans
Supply:	R1	7	15	6	Supply: R1	Pr	0.74615	-0.2	0.3
	R2	15	14	4		Pm	-0.2	0.7	0.2
						Pb	-0.3	0.2	0.4
Demand:	R1	15	11	3	Supply: R2	Pr	0.3	-0.1	-0.1
	R2	20	18	7		Pm	-0.1	0.2	0.3
						Pb	-0.1	0.3	0.2
Imports		13	0	0	Demand: R1	Pr	-0.62308	0.1	0.0
						Pm	0.1	-0.6	-0.2
						Pb	0.0	-0.2	-0.5
					Demand: R2	Pr	-0.3	0.2	0.0
						Pm	0.2	-0.3	-0.3
						Pb	0.0	-0.3	-0.3

INITIAL PRICES:	Rice	Maize	Beans
Domestic	231.80	266.00	400.0
Border	231.80	266.00	400.0

Table 5.5: Combined Regional and Three-Commodity Model

CALCULATIONS BLOCK (Combined Regional and Three-Commodity Model)

MATRICES:

G Matrix			U Matrix		Inverse G Matrix		
-8.4	-3.6	13	-25.07	-9.7	0.0	0.1	-0.2
25.3	14.8	0	9.1	4.4	0.0	-0.1	0.3
5.1	6.8	0	2.2	2.2	0.1	0.0	-0.0

Solution Matrix

0.3	-0.0
0.1	0.3
-1.7	-0.7

POLICY CHANGE: % Change in Exogenous Variables — Rice Pr 10; Subsidy S 0

OUTCOME:

% Change in Endogenous Variables		New Levels of Endogenous Variables		National Totals	
Pm	3.04	Pm	274.08	Sr	22.85
Pb	0.96	Pb	403.83	Sm	29.03
Sr1	6.57	Sr1	7.46	Sb	9.88
Sr2	2.60	Sr2	15.39	Dr	33.63
Sm1	0.32	Sm1	15.05	Dm	29.03
Sm2	-0.11	Sm2	13.99	Db	9.88
Sb1	-2.01	Sb1	5.88	Mr	10.78
Sb2	0.10	Sb2	4.00		
Dr1	-5.93	Dr1	14.11		
Dr2	-2.39	Dr2	19.52		
Dm1	-1.01	Dm1	10.89		
Dm2	0.80	Dm2	18.14		
Db1	-1.09	Db1	2.97		
Db2	-1.20	Db2	6.82		
Mr	-17.06	Mr	10.78		

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

Under contract to U.S.A.I.D., Bureau of Science and Technology, Office of Agriculture
Project Office: Hampden Square, 4800 Montgomery Lane, Suite 500, Bethesda, MD 20814
Telephone: (301) 913-0500 • Telex: 312636 • Fax: (301) 652-3839 • Fax: (301) 652-7791

[redacted]

AGRICULTURAL AND NATURAL RESOURCES POLICY ANALYSIS COURSE

Learning Spreadsheets
Analyzing Aggregate Data

Methods and Guidelines No. 401

Volume 3

Prepared for: Agricultural Policy Analysis Project, Phase II (APAP II)
A.I.D. Contract No. DAN-4084-Z-00-8043-00

Authors: Rosamond Naylor
Carl Gotsch

Prime contractor: **Abt Associates, Inc.**, 55 Wheeler Street, Cambridge, MA 02138 • (617) 492-7100

Subcontractors:

Harvard Institute for International Development, Harvard University, One Eliot Street, Cambridge, MA 02138 • (617) 495-2164
Food Research Institute, Stanford University, Stanford, CA 94305-6084 • (415) 723-3941
North Carolina State University, Department of Economics and Business, Box 7645, Raleigh, NC 27695-7645 • (919) 737-7187
Abel, Daft & Earley, 1410 King Street, Alexandria, VA 22314 • (703) 739-9090
International Science and Technology Institute, 1129 20th Street, NW, Suite 800, Washington, D.C. 20036 •(202) 785-0831
International Food Policy Research Institute, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036 • (202) 862-5600

TABLE OF CONTENTS

PREFACE iii

CHAPTER 1: LOTUS 1-2-3: A DEMONSTRATION 1
THE LOTUS MENU 1
RETRIEVING A DATA FILE 2
MOVING AROUND THE SPREADSHEET 3
LABELS AND NUMBERS 3
USING FORMULAS 4
LOTUS GRAPHICS 5
PRINTING IN LOTUS 1-2-3 5
LOTUS ADD-IN PROGRAMS 7
SUMMARY 7

CHAPTER 2: LEARNING LOTUS 1-2-3 17
ENTERING NUMBERS 17
ENTERING LABELS 17
INSERTING ROWS AND COLUMNS 19
MOVING DATA 20
ERASING DATA 22
REALIGNING LABELS AND EDITING CELLS 22
EDIT COMMAND KEYS 23
FORMATING DATA 25
SUMMARY 27

CHAPTER 3: CREATING AN AGGREGATE DATABASE 28
CREATING A TABLE 28
ENTERING DATA 31
CALCULATING PRODUCTION 32
FORMATING PRODUCTION DATA 34
CALCULATING GROSS REVENUE 35
CREATING RANGE NAMES 36
PRINTING TABLES 38

CHAPTER 4: DISAGGREGATING AGRICULTURAL SECTOR DATA 42
COMPUTING REGIONAL PRODUCTION ESTIMATES 42
GRAPHING REGIONAL PRODUCTION STATISTICS 45

CHAPTER 5: COMPUTING STATISTICAL MEASURES AND TRENDS 48
COMPUTING SUMMARY MEASURES 48
REGRESSION ANALYSIS FOR TREND CALCULATIONS 49
COMPUTING TREND VALUES FOR AGRICULTURAL PRODUCTION 52
GRAPHING PRODUCTION TRENDS 52
PRINTING THE GRAPH 53
COMPUTING A GROWTH RATE 54

CHAPTER 6: ANALYZING AGGREGATE OUTPUT 56
TRENDS IN THE VALUE OF AGRICULTURAL OUTPUT 56

DECOMPOSING AGGREGATE OUTPUT 57

PREFACE

The computer exercises in this volume have two objectives. First, they serve as an introduction to the use of electronic spreadsheets. The treatment is brief and it is not intended to be a reference for Lotus 1-2-3 or any of the other spreadsheets that can emulate 1-2-3. Books such as Lotus Development Corporation's *Learning Lotus 1-2-3* or Que's *Using Lotus 1-2-3* serve that purpose. Rather, the initial exercises focus on a sub-set of concepts and commands that will be especially useful in the subsequent policy analysis series. Thus, if students find themsevles doing more "moving" and "copying" than the initial simple problems seem to call for, it is all part of an effort to practice the tools and techniques that will be helpful later on.

This manual also has a substantive agenda. Subsequent volumes in this series take up more sophisticated analytical tools such as the policy analysis matrix (PAM), market-level analysis, and mathematical programming. However, for anyone interested in policy, there is much to recommend an examination of aggregate data as an initial step. It is highly desirable, for example, to establish what has happened over time to aggregate output, yields, the compostion of output, input use, prices, etc. Often much that is of relevance to the policy environment can be seen from the calculation of percentages and simple trends. These analyses are quite straightforward and involve simple arithemetic that can be carried out easily on spreadsheets. The substantive work therefore complements the first objective of acquiring a familiarity with spreadsheets on microcomputers.

The manual begins with a brief introduction to Lotus 1-2-3 on microcomputers. It is designed to be led by an instructor and to provide students with an overview of the computations and presentations that will be developed in subsequent hands-on work. In the absence of the instructor, students may wish simply to read the material and go on to the introductory exercises in Chapter 2. The material in Chapters 3-5 progresses from the development of a small database to the computation of the components of agricultural growth for particular time periods. To reiterate, this manual is not a substitute for the detailed tutorials that are supplied with most spreadsheet software. It is also not a substitute for having a Lotus manual nearby to consult when something goes awry.

The exercises can be carried out on a wide variety of microcomputers. Lotus 1-2-3 (Version 2.2) is the point of departure and it is assumed that students will be working on IBM or IBM compatible machines. Spreadsheets such as Borland's QuattroPro and Computer Associates' SuperCalc contain Lotus emulation modes that make it possible to utilize the manual's instructions without change. Spreadsheets such as Excel or Wingz running on the Apple Macintosh work equally well as far as the calculations are concerned, but some translation of specific instructions will be required.

For those unfamiliar with Lotus 1-2-3 commands, the Quick Reference section of the Lotus manual has been bound as a part of this volume. It can be found at the back of the manual.

Thanks are due to the Agricultural Policy Analysis Project (APAP), funded by U.S.A.I.D., for providing the resources to prepare this manual and to carry out the training exercise. Further information about this project, its newsletter and its published output in the agricultural policy field can be obtained from Abt Associates, Inc., Hamden Square, 4800 Montgomery Lane, Suite 600, Bethesda, MD 20814.

Carl H. Gotsch
July, 1991

CHAPTER 1: LOTUS 1-2-3: A DEMONSTRATION

The following exercise provides an overview of some of the most important features of Lotus 1-2-3.[1]

Like all spreadsheets, columns and rows identify the **cell address** of each data entry. A repeating alphabet (e.g., A, B, C...IV) goes up to 256 columns horizontally; the vertical scale has 8192 rows. A1 refers to Column A, Row 1; AB2 refers to Column AB, Row 2. In subsequent exercises, you will be asked to enter data yourselves. However, in the following introductory sequence, the contents of the data file have been stored on a diskette under the file name "**INTRO**" and the file need only be retrieved in order to follow the demonstration. Insert the "Intro" diskette into drive A if you have not already done so.

At the DOS prompt C:\, type **Lotus**. In its command structure, Lotus 1-2-3 does not distinguish between upper and lower case fonts. You could also have typed LOTUS or lotus.

After you have typed LOTUS, the computer will work for a few seconds and then produce a menu of choices. Choose 1-2-3.

THE LOTUS MENU

Lotus is a menu driven program. The menu contains a series of commands which appear at the top of the screen. The first step in retrieving the data file is to retrieve the menu.

Press: / {slash}

Below the main menu is a sub-menu showing options at a lower level. For example, if the cursor is on ***Worksheet***, the menu will appear as it does on Screen 1.1:

Notice that the word MENU is shown in the top right hand corner of the screen. This indicates that the only action that can be taken is to select from the menu. If data are to be entered, the word READY must show in the upper right hand corner.

RETRIEVING A DATA FILE

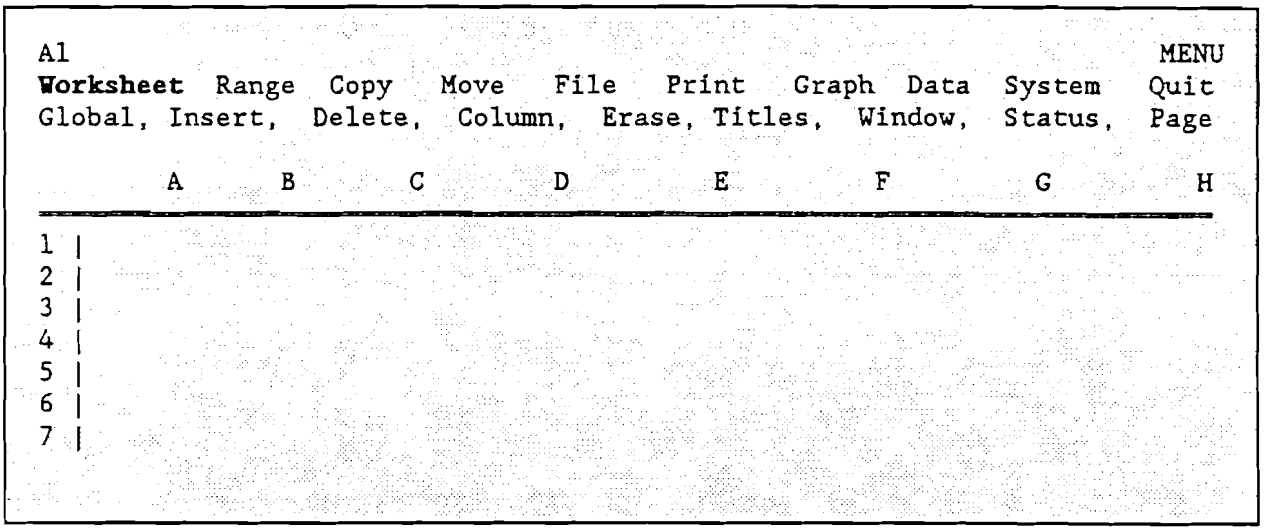
The data file can be retrieved in one of two ways:

(1) Move the cursor to the word ***File*** with the arrow keys and press **[Enter]**,

or

[1] Chapter 1 is not intended to be a self-teaching tutorial. It will ordinarily be carried out with the instructor as an interactive demonstration of the capabilities of electronic spreadsheets. If self-taught, it requires a diskette containing the file INTRO.WK1. This diskette should be inserted in Drive A: after the DOS prompt has appeared and before Lotus 1-2-3 is started.

Screen 1.1



(2) Type the first letter of the command, ***F.***

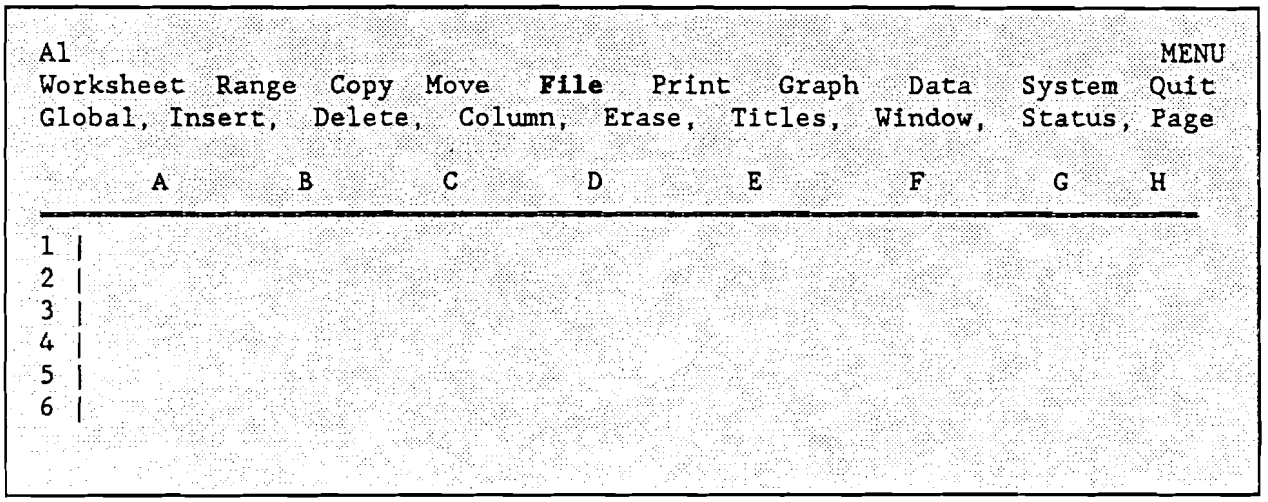
When the file sub-menu appears, retrieve the file. Again, there are two choices:

(1) Move the cursor to ***Retrieve*** with the arrow keys and press [**Enter**],
or

(2) Type the first letter of the command, ***R.***

The computer will then display a list of file names. Select **INTRO.WK1** by highlighting with the arrow keys and press [**Enter**]. (Note that all Lotus 1-2-3 spreadsheet files end in **.WK1**.)

Screen 1.2



MOVING AROUND THE SPREADSHEET

There are several ways to move the cursor around the spreadsheet. Practice using the following commands. (If the arrow keys are on the numerical keypad, make sure that the [**Num Lock**] switch is off.)

(1) The [**Home**] key returns the cursor to the cell, A1.

(2) The [**End**] key followed by the [**Home**] key moves the cursor to the lower right corner of the last table.

(3) The [**PgUp**] and [**PgDn**] keys move the cursor up and down the spreadsheet in lengths of screen.

(4) [**F5**], the {GOTO} function key, moves the cursor to a specified cell. (This key will become important later when there are a number of tables on a single spreadsheet and the analysis requires moving quickly from one to another.)

Press: [**F5**]
Type: ***D3***
Press: [**Enter**]

The cursor will move to the word "Production" in cell D3 of **INTRO.WK1**.

(5) The cursor can be moved rapidly around the spreadsheet by using it in conjunction with the [**Ctrl**] key. Hold down the [**Ctrl**] key and press the left or right arrow key. The cursor moves a screen at a time.

It is important to develop the habit of moving the cursor in the most efficient way possible. Your productivity will be much enhanced if you are able to locate tables and cell entries quickly.

LABELS AND NUMBERS

Three types of data may be entered in a Lotus 1-2-3 spreadsheet.

(1) **Labels** are words or symbols that are not used for calculations. All labels have prefixes that determine their position in a cell. The prefixes are ', ", or ^.

(a) The ' prefix aligns the label on the left hand side of the cell. It is the default that Lotus uses if no other command is given.

(b) The " prefix aligns the label on the right hand side of the cell.

(c) The ^ prefix aligns the label in the center of the cell.

Press: [**Home**] Notice the label prefix (') in cell A1 at the top of the screen where the cell contents are displayed.

Press: **[F5]** {GOTO} and type **A6**. Notice the numbers entered here as dates also have a label prefix. This is because they are not going to be used for calculations.

(2) **Values** are numerical entries that will be used in computations. They do not have prefixes. Move the cursor to a numerical entry with the arrow key and verify that the cells containing numbers do not have a prefix.

(3) **Formulas** are cell entries whose values are obtained by computation from other values in the spreadsheet. Move the cursor to the column under the heading: "Production." The formula used to calculate the values in the column will appear in the upper left hand corner of the screen. The formulas need only be entered in the first cell of the column. The ***Copy*** command can be used to copy them into other cells, making it possible to construct spreadsheets rapidly.

Formulas must be written with a mathematical sign before the first value, such as +, -, (or @. The @ sign indicates that a specific Lotus 1-2-3 function for computing numerical values is to follow.

USING FORMULAS

The power of a spreadsheet results from the ability to insert formulas that compute cell values from data stored in other cells of the worksheet. For example, move the cursor to numbers in the column labeled "Production" and note the formulas displayed in the upper left hand corner of the screen. Row and column designations that have a dollar sign prefix ($) are called "**absolute**" addresses. This means that when they are copied, they will continue to reference the cell address given in the formula without automatically adjusting to the changes in "relative" cell position. If there are no $ signs in front of row and column indentifiers, the computer will automatically change the cell addresses to reflect the changes in the "**relative**" position of the target cells.

Understanding the ***Copy*** command is crucial to building policy analysis models quickly and accurately. To see its power:

Press: **[F5]** {GOTO}
Type: F6
Press: **[Enter]**
Type: +D6*E6/1000
Press: **[Enter]**

The result of the multiplication will appear in Cell F6. Now:

Press: /
Select: ***Copy***
"Range to copy FROM: F6..F6" [2]

[2] Thoughout the manual, quotes indicate Lotus 1-2-3 prompts.

Press: [**Enter**]
"Range to copy TO: F6"
Press down arrow once to move to F7
Press: . (anchor the range)
Press: [**Down Arrow**] (highlight to the bottom of the column)
Press: [**Enter**]

Notice that the copied cell addresses have changed to reflect the formula's position **relative** to the cells in the original formula.

LOTUS GRAPHICS

To see a graph of the data in the spreadsheet, call the main menu:

Press: /
Select: ***Graph***
View

A graph of the data from the spreadsheet will appear on your screen. The data for this graph have been entered previously. The graph presents, not only the data on aggregate production and acreage shown earlier, but a graph of the trend line through the data. The trend values have been estimated from the coefficients of the equation [Y = a + bX] computed using Lotus 1-2-3's regression capability. The calculated Y values of the trend line are shown under the column "Trend" in the "INTRO.WK1" worksheet.

Graphs may be saved in two ways:

(1) As part of the worksheet when the worksheet is saved. (If there is more than one graph, each must have been saved as a "named" graph.)

(2) As a **.PIC** file that can be printed with the Lotus module, **PrintGraph.** (**.PIC** is a standard data format that can be read by many other packages including word processors such as WordPerfect or Microsoft Word. This makes it possible to import graphs into reports and research papers.)

Remember that saving the graph as a file to be printed (.PIC) does not mean the graph has been saved in its worksheet form. Similarly, saving the graph in the worksheet does not mean it can be printed. Much work can be lost by failing to save properly.[3]

PRINTING A TABLE IN LOTUS 1-2-3

Tables may be sent either directly to the printer or to a file for subsequent incorporation in text documents. To print,

[3] Newer spreadsheets such as Quattro, Excel and SuperCalc5 allow graphs to printed directly from the spreadsheet.

152

Press: /
Select: ***Print***
Printer

The sub-menu offers several different output formats. Once the range, i.e., the rows and columns to be included in the printout, has been set, such parameters as margins, headers and footers, length of page, size of type, etc., may be chosen. The printer is activated by selecting: ***Go***. (Printers may be stop by pressing the **[Control]** key and the **[Break]** key simultaneously.)

Worksheets may also be printed as a file that can subsequently be read by a wordprocessor. The command sequence is **/Print File** instead of **/Print Printer** . The result will be an ASCII file with the extension **.PRN** that can be retrieved by such programs as WordStar, WordPerfect and Microsoft Word.

PRINTING A GRAPH IN LOTUS 1-2-3

To print a graph, you must exit the Lotus 1-2-3 program and enter the **PrintGraph** program. Before leaving 1-2-3, remember to save your work.

Select: ***File***
Save

The full path name of the file is **A: \INTRO.WK1**. When asked whether to **Cancel** or **Replace,** anwer "Replace" if new work has been added and the old file should be overwritten. (Note: Accidentally replacing a file with a blank spreadsheet will wipe out previous work.)

Now exit Lotus 1-2-3.

Select: ***Quit***
Yes

From the Lotus program menu,

Select: ***PrintGraph***

The Printgraph menu will appear on the screen.

Select: ***Image-Select***

A list of files will appear on the screen

Move the cursor to **INTRO** and press **[Enter]**.

Select: ***Align***

Screen 1.3

```
                                                                    MENU
Select Graphs for Printing
Image-Select      Settings      Go      Align      Page      Exit
-
INTRO
```

Go

The graph from Lotus 1-2-3 will be printed. (Printing graphs is quite slow. To stop the printer, press [**Ctrl**]-[**Break**].)

To leave the Printgraph program,

Select: ***Exit***
Yes

LOTUS ADD-IN PROGRAMS

Lotus 1-2-3 (Version 2.2) is an upgrade to what is sometimes called a "second generation" spreadsheet. It is an improvment over first generation spreadsheets such as VisiCalc, but does not have many of the features contained in such third generation spreadsheets such as Excel and Lotus 1-2-3 Version 3. However, because of modest hardware requirements, Version 2 is still the most popular spreadsheet currently in use on microcomputers.

In an effort to improve its printing performance, a number of third-party software vendors have written programs that can be used in conjunction with Lotus 1-2-3. They are called "add-in" programs because they can be invoked from within Lotus by the use of a "hot key." One of the most popular of such packages is AllWays.

To run Allways:

Press: [**Alt**]-[**F7**]

AllWays uses the same type of menu system as Lotus 1-2-3. It permits a wide range of fonts and formatting commands to be used with the spreadsheet currently on the screen and in memory. Print ranges, margins, etc., are set in the same way that they are set in Lotus. Control is returned to the spreadsheet by pressing [**Esc**].

Print the **INTRO** file using Allways. Use the commands described earlier in the directions on how to print a Lotus table.

SUMMARY

Chapter 1 highlights some of the most important attributes of Lotus 1-2-3. Experienced spreadsheet users will, of course, already be aware of the power of the Copy command, the need to distinguish between relative and absolute cell addresses, the importance of saving graphs in both the spreadsheet and .**PIC** formats, etc. For new users, the demonstration serves to create an awareness of the capabilities of spreadsheets and the skills that participants will acquire in carrying out the exercises in this and other workbooks in the series.

CHAPTER 2: LEARNING LOTUS 1-2-3

The exercises in Chapter 1, carried out with the help of the instructor, displayed some of the features of Lotus 1-2-3. In Chapter 2, you will be asked to type in data and execute the commands yourself.

ENTERING NUMBERS

Enter the number 2800 into the cell A1. As the number is typed, the word **VALUE** will appear in the top right hand corner of the spreadsheet and the number will appear in the top left corner. When the number as been typed in, press **[Enter]** and the number will be entered in cell A1 of the spreadsheet. The indicator will return to **READY**.

Screen 2.1

```
A1  2800                                                          VALUE
      A        B        C        D        E        F        G        H
=================================================================
1 |
2 |
3 |
4 |
```

Data can also be entered into a cell by pressing the **Arrow Keys** after typing in the values. For example, move the curser to the cell A2. Enter the value 3000. Press the **[Down Arrow]** The number will be entered in the spreadsheet and the cursor will jump down one cell in preparation for entering the next value.

Screen 2.2

```
A2  3000                                                          READY
      A        B        C        D        E        F        G        H
=================================================================
1 |  2800
2 |  3000
3 |
4 |
```

Practice typing numbers and moving around the spreadsheet.

156

ENTERING LABELS

Remember that labels are always identified with a **label prefix**, e.g, ' (apostrophe), " (quote), or ^ (caret). If the cell entry begins with an ', the label will be left justified; if it begins with a ", it will be right justified. If it begins with ^, it will be centered. Unless told otherwise, Lotus 1-2-3 assumes that any entry beginning with a letter is a label and will place it on the left hand side of the cell because the default label prefix is an apostrophe (').

If the cell entry begins with a number or an arithmetical operator such as +, -, *, (, and is intended to be a label rather than a value or a function, a label prefix must be typed in preceding the number.

Move the cursor to cell A3.

Type: **Area**
Press: **[Enter]**

Notice that the word is identified as a **LABEL** when it is being typed. When the [**Enter**] key is pressed, the status indicator on the right returns to **READY** indicating that another operation can be performed.

Screen 2.3

```
A1  'Area                                                        READY

      A        B        C        D        E        F        G        H
-------------------------------------------------------------------------
1 |  2800
2 |  3000
3 |Area
4 |
5 |
```

Move the cursor to cell A4.

Type: **Yield**
Press: **[Down Arrow]**

Numerical dates can be entered as labels by adding a "label prefix" before the number.

Type: **'1970**
Press: **[Down Arrow]**

Type: **'1971**
Press: **[Enter]**

Notice that the numbers preceded by an apostrophe (') are aligned on the left-hand side of the cell just as the word **Area** is.

To see why the use of labels prefixes is important, move to cell A7 and enter a date separated by a / (slash). For example:

Type: **'7/4/89**
Press: **[Down Arrow]**

Type: **7/4/89** (no prefix)
Press: **[Enter]**

The result in the A7 cell will be a data label. The result in the A8 cell will be a number: .019662. The machine divided 4 into 7 and 89 into the answer to the first division.

Screen 2.4

```
A1 '1971                                                          MENU

     A        B        C        D        E        F        G        H
=================================================================
1 |    2800
2 |    3000
3 |Area
4 |Yield
5 |1970
6 |7/4/89
7 |.019662
8 |
```

There are a number of commands in Lotus 1-2-3 that can be used to change the appearance of a spreadsheet. Data can be moved around the spreadsheet, edited, and re-aligned. Rows and columns can be inserted and deleted. The following section provides some practice in using these commands.

INSERTING ROWS AND COLUMNS

Move the cursor to the top of the spreadsheet (cell A1) by pressing **[Home]**.
Press: / (slash)
The main menu will appear.

Select: ***Worksheet***
Insert
Row
Press: **[Enter]**

158

The row below the cursor will be shifted down by one row, placing a new empty row at the cursor. More than one row can be inserted at a time. With the cursor at A1:

Press: /
Select: ***Worksheet***
Insert
Row

The command "Enter row insert range: A1 . . A1" will appear above the spreadsheet:

The current range starts and ends with row 1. Move the cursor to row 2. The range will now be **A1 . . A2**, rows 1 and 2.

Screen 2.5

```
A2:  2800                                                        POINT
Enter row insert range:  A1 . . A2

        A       B       C       D       E       F       G       H
 1|
 2| 2800
 3| 3000
 4|Area
 5|Yield
 6|1970
 7|1971
 8|
```

Now press **[Enter]** and Lotus will insert two rows instead of one. The same procedure is used to delete rows with the ***/Worksheet Delete Row*** command. Delete one of the two inserted rows.

MOVING DATA

Numbers and labels can be moved around the spreadsheet as individual cells or as blocks of cells described by "ranges." Begin by moving the word **Area** from cell A4 to cell B1.

Move the cursor to **Area.**
Press: /
The main menu will appear.
Select: ***Move***
Press: **[Enter]**
"Enter range to move from: A4..A4"

Press: **[Enter]**
"Enter range to move to: A4."

When asked for the target cell, move the cursor to cell B1 and press **[Enter]**. Now move the cursor to the word **Yield**.

Type: /
Select: ***Move***
[Enter]

Move the cursor to cell C1 and press **[Enter]**.

Screen 2.6

```
C1:                                                                  READY

        A        B        C        D        E        F        G        H
 ------------------------------------------------------------------------
 1|              Area     Yield
 2|
 3|
```

Moving a Block of Cells with the Range Command

A range is a cell or rectangular group of contigious cells located side-by-side in the spreadsheet. A range can be one cell, a single row or column of cells, or a block of cells consisting of many rows and columns. However, a range must be a **rectangular block**.

To define a range within a command, move the cursor to the beginning of the range, type a period (.) to **anchor** the range, and move the cursor over the other cells that you want included in the range until it is completely highlighted. To see how this works,

Select: ***Move***

The computer will respond by asking, "Enter range to move from: A1 . . A1"

Press: **[Escape]**
Move the cursor to 2800
Type a period: .
Move the cursor down until both 2800 and 3000 are highlighted.
Press: **[Enter]**

The computer prompt will ask "Move To"
Move the cursor to cell B3. This identifies the beginning of the range.
Press: **[Enter]**

160

The numbers will be moved into column B under **Area**.

Now move the dates 1970 and 1971 to cell A3 and A4 respectively so they will be aligned with the area figures. Use the same move commands that you just used to move the area figures.

You spreadsheet should now look like the one in Screen 2.7.

Screen 2.7

```
A1 '1971                                                                MENU

      A        B        C        D        E        F        G        H
-------------------------------------------------------------------------
1 |          Area      Yield
2 |
3 |1970        2800
4 |1971        3000
5 |
6 |
7 |
8 |
```

Note: If data are moved into a cell which already has data in it, *the data in the receiving cell will be overwritten*. This makes ***Move*** one of the more dangerous commands in Lotus 1-2-3.

ERASING DATA

Labels, numbers, and formulas can be erased in a spreadsheet by using the ***Range Erase*** command. Practice by erasing the cells that contain 7/4/89 and .019662.

Move To: **7/4/89**
Select: ***Range***
Erase

Now highlight the range (block) that is to be erased.
Type a period: .
Move to: **.019662**
Both numbers will now be highlighted.

Press: **[Enter]**

REALIGNING LABELS AND EDITING CELLS

Labels can be re-aligned from the left-hand side of the cell to the right-hand side of the cell by using the **Edit** command [F2].

Move to: **B1 (Area)**

161

Press: **[F2]**

[F2] is an important key; it puts you in the **Edit** mode. The word **EDIT** will appear in the top right-hand corner of the screen.

Use the Home key to move the cursor to the label prefix (') in the top left-corner of your screen.

Press: **[Del]**
Type: "
Press: **[Enter]**
The label will now be aligned to the right-hand side of the cell. Do the same for **Yield.**

EDIT COMMAND KEYS

The following keys can be used when editing entries:

1) **[F2]**	Start editing. The word edit appers in the top of the screen.
2) **[Enter]**	Ends editing. Replaces the original entry with the edited one.
3) **[Esc]**	Ends editing and leaves the original entry intact.
4) **[Backspace]**	Erases the character to the left and moves left.
5) **[Del]**	Erases the character above the cursor.
6) **[Home]**	Moves to the first character of the entry.
7) **[End]**	Moves to the last character of the entry.
8) **[Arrows]**	Move one space at a time: left, right, up, down.

Setting the Column Width

The width of each column in the Lotus 1-2-3 worksheet is set by default to 9 characters. This setting can be changed to make the width of the column smaller or larger. To see how this is done, change the width of column A to 6 characters. Move the cursor to column A.

Press: /
The main menu will appear.
Select: ***Worksheet***
Column
Set-Width

Type: **6**
Press: **[Enter]**

The width of column A is now set at 6 characters.

Alternatively, instead of entering a number, the arrow keys can be used to set the column width. This method makes it easy to judge how wide the column needs to be in order to accommodate the proposed entry.

Screen 2.8

```
A1 [W9]                                                                MENU
Enter column width (1..240): 9

      A      B        C        D        E        F        G        H
1 |          Area     Yield
2 |
3 |1970
4 |
5 |
```

Drawing lines under headings

The appearence of a spreadsheet can be improved by drawing lines under headings to separate the headings from the data. Lotus 1-2-3 does not have a special underline command, so additional cells below the headings must be used to draw the lines. Single or double lines can be drawn, using the hyphen or equal-sign character.

Move to:	**A2**	
Type:	\-	(a backslash followed by a hyphen). Note this backslash key is different from the slash key used to call up the menu.
Press:	**[Enter]**	

A line will appear across the entire width of the cell. The backslash is a special label prefix that repeats the character following it across the entire cell.

Screen 2.9

```
A1  /-                                                                ENTER

      A        B        C        D        E        F        G        H
1 |            Area     Yield
2 |----------
3 |Area
4 |Yield
5 |1970
6 |7/4/89
7 |.019662
8 |
```

The line can be entered into cells to the right using the *Copy* command. With the cursor in cell A2,

Press: /
From the main menu,
Select: *Copy*
Press: **[Enter]**

"Enter the Range to Copy TO: A2...A2"
Press: **[Enter]**
Move to: **B2**
Type a period: .
Move to: **C2**
Press: **[Enter]**

Double lines can be drawn in the same way by entering \=, i.e. a backslash followed by an equal sign, in the cell. Any characters entered after the backslash will be repeated across the cell.

FORMATING DATA

Before learning how to format data, add the following data on yields.

Move to: **C3**
Type: **3**
Move to: **C4**
Type: **3.2**

Screen 2.10

```
C4  3.2                                                                ENTER

      A        B        C        D        E        F        G        H
=================================================================================
1 |            Area     Yield
2 |-----------------------------
3 |1970        2800     3
4 |1971        3000     3.2
5 |
6 |
```

Format the data on yields such that both numbers have one decimal place.

Move to: **C3**
Press:: /
From the main menu,
Select: ***Range***
Format
General

164

The **Range Format** menu will appear. Press **[Enter]** to select a fixed number of decimal places.

Screen 2.11

```
C3: 3                                                                  MENU
Fixed  Scientific  Currency  ,  General  +/-  Percent  Date  Text  Hidden
Fixed number of decimal places (x.xx)

        A        B        C        D        E        F        G        H
-------------------------------------------------------------------------
1 |    2800
2 |    3000
```

The following command will appear:

"Enter number of decimal places (0 . . 15): 2"
Type: **1**
Press: **[Enter]**
"Enter range to format C3 . . C3"
Move to: **C4**
Press: **[Enter]**

The yield numbers will now display one decimal place. (The default value is two decimal places.) Data can also be formatted by ranges or for the entire worksheet. To format all of the numbers in the worksheet, the following commands are used:

Type: /
Select: ***Worksheet***
Global
Format

The same sub-menu will appear as above. The following list contains some of the options available with the **Format** command.

Fixed	Rounds to a fixed number of decimal places: 89.09
Scientific	Exponential notation: 2.45E+04
Currency	Dollars and cents: $4.35
,	Adds commas to long numbers: 3,456,898 and places negative values in parentheses
General	No fixed number of decimal places (the initial setting format)
Percent	Multiplies by 100 and adds a % sign: .36 = 36%
Date	Formats into one of several date formats: DD-MMM-YY
Reset	Returns to global default format

165

SAVING A FILE AND EXITING

When work on the spreadsheet is complete, or as a precautionary measure to prevent accidental loss of work, the worksheet must be saved. Alternative "Save" choices are under the **FILE** heading on the menu tree. Chosing SAVE will bring up a sub-menu with three choices: Cancel, Replace and Backup. Choosing Cancel will void the save command. The spreadsheet will remain on the screen and no work will be lost. If Lotus 1-2-3 has previously saved a file under the suggested name, it will first ask whether it should write over the old file with the new material in the machine's memory. If this is desired, the choice should be Replace with a following Yes. If a second copy of the file is desired, the choice is Backup. The file will be saved with the extension, <Filename.BAK>. It can be retrived and used by renaming it to <Filename.WK1>.

SUMMARY

This chapter introduced a number of commands that are useful for editing data and changing the appearence of a spreadsheet. These include inserting and deleting rows and columns, moving data around the spreadsheet, erasing data from a cell, realigning data within cells, underlining headings, and formatting numbers. The need for tools that permit flexibility in worksheet construction will become more apparent in the following chapters.

CHAPTER 3: CREATING AN AGGREGATE DATABASE

This section consists of a series of spreadsheet exercises using agricultural sector data from Indonesia. The data include area, yields, and prices for the following crops: palay, maize, and mungbeans. All of the crops can be grown in lowland rainfed or irrigated fields and therefore act as substitutes in production during certain seasons. The data in this chapter are aggregated across all agro-climatic zones and seasons. This provides an overall picture of national trends but it obscures the dynamics of the agricultural sector at the regional and farm level. Various methods of disaggregating national data are discussed in subsequent chapters.

CREATING A TABLE

The following steps create the column headings for a table called Philippine Food Crops Sector.

Screen 3.1

```
D8                                                                  READY

        A         B         C         D         E         F         G         H
1 |Philippine Food Crops Sector
2 |
3 |Wetseason Palay
4 |
5 |Year          Area      Yield     Production
6 |              ('000 ha) (kg/ha)   ('000 mt)
7 |
8 |
```

Press:	**[Home]**
Type:	**Philippine Food Crops Sector**
Press:	**[Down Arrow] [Down]**
At:	**A3**
Type:	**Wetseason Palay**
Press:	**[Down Arrow] [Down]**
At:	**A5**
Type:	**Year**
Press:	**[Right Arrow]**
At:	**B5**
Type:	**Area**
Press:	**[Right Arrow]**

167

At: **C5**
Type: **Yield**
Press: **[Right Arrow]**

At: **D5**
Type: **Production**
Press: **[Enter]**
Setting Column-Widths:

Notice that **Production** has more than 9 characters and thus exceeds the limit of the column. Expand the column to 13 characters.

Press: /
Select ***Worksheet***
Column
Set-width
Type: **13**
[Enter]

The column will now be 13 characters in width.

Fill in the measurement units for Area, ('000 ha); Yield, (kg/ha); and Production, ('000 mt) in row 6. (Remember, in order to have numbers or arithematical operators such as +, -, (, etc., appear as labels, they must be preceeded by an apostrophe.)

Lines under headings

Move to: **A7**
Type: \- (backslash followed by a hyphen)
Press: **[Enter]**

Copy across to each column using the copy command.
Press: /
Select: ***Copy***
Press: **[Enter]**

"Enter range to copy TO: A7"
Move to: **B7**
Type a period .

Move cursor along row until columns B through D are highlighted (range B7..D7)
Press: **[Enter]**

Entering Dates

Enter the dates in column A. Dates can be entered either as labels (as in the previous chapter) or as values. To enter dates as labels, type ' before the year in each row. To enter dates as values, which this exercise requires, use the ***Data Fill*** command as follows:

Move to:	**A8**
Press:	/
Select:	***Data***
	Fill
Press:	**[Enter]**

The following prompts will appear in the top panel:

"Enter fill range: A8"

Complete the range by typing a period (.) and moving the cursor down until 11 cells are highlighted (i.e., enough room for the years 1976 to 1986).

"Start: 0"	Type:	**1979**
"Step: 1"	Press:	**[Enter]**
"Stop: 8191"	Type:	**1989**
	Press:	**[Enter]**

The dates, when entered as values, will be aligned on the right hand side of the cell and may appear with decimal places. To eliminate the decimal places, use the ***Range Format Fixed*** command.

Press:	/
Select:	***Range***
	Format
	Fixed

"Enter number of decimal places (0 .. 15): 2"

Type:	**0**

"Enter range to format: A8 . . A8"

Move the cursor to the bottom of the column so that the years are highlighted and press **[Enter]**.

Once the table format for Wetseason Palay is complete, save the spreadsheet.

Press:	/
Select:	***File***
	Save
Type:	**Phil**
	[Enter]

It is important that the worksheet be saved periodically. Because the worksheet is held in

RAM memory, all previous work will be lost if the power fails or if you hit the wrong key sequence.

Copying Tables

Once the table format has been created for the first crop, it can be copied easily for other crops. Copy the table formats before entering the data. Once the table format has been copied, the name of the table can be changed and the data altered. *Be sure you understand the Copy command.* It is one of the most powerful features of spreadsheets. Its mastery adds greatly to the speed with which worksheets can be constructed. (Figure 3.1 shows how the partially completed worksheet will look.)

Move to: **Wetseason Palay**
Press: /
Select: *Copy*
"Enter range to copy from: A3 . . A3"

Move the cursor down the rows until the last data item is highlighted, then move it to the right until the column entitled **Production** is highlighted (A3 . . D18).

Press: **[Enter]**
"Enter range to copy to: A3"
Press: **[PgDn]**
[Enter]

The table format will now be copied one screen length below the first table.

Move to the second table by pressing **[PgDn]**.

Type: **Dryseason Palay** in place of **Wetseason Palay**.
Press: **[Enter]**

Copy this table one page length down for Maize. Do the same for Mungbeans using the instructions above. Be sure to type in the correct titles for each table. A good time to **save the worksheet** is after the tables have been copied. It is also a good time to make a second copy of the spreadsheet. To make a copy, save it again under another name.

ENTERING DATA

Use the data in **Data Table 3.1** at the end of the Chapter to enter the figures for area and yield of the three crops into the tables that have been created. Note that Table 3.1 is a data table containing numbers; it is not intended to represent a screen. For each table, it is easiest to enter the data by column, using the **Down Arrow** to move from one number to the next. The data will be entered automatically as numbers (as opposed to labels or formulas). Another good time to save your work is after the data have been entered.

Figure 3.1: Partial Worksheet Showing Food Sector Tables

	A	B	C	D	E	F	G	H
1	Philippine Food Crop Sector							
2								
3	Wetseason Palay							
4								
5	Year	Area	Yield	Production				
6		(000 ha)	(kg/ha)	(000 mt)				
7	---	---	---	---	---	---	---	---
8	1979							
9	1980							
10	1981							
11	1982							
23	Dryseason Palay							
24								
25	Year	Area	Yield	Production				
26		(000 ha)	(kg/ha)	(000 mt)				
27	---	---	---	---	---	---	---	---
28	1979							
29	1980							
30	1981							
31	1982							
43	Maize							
44								
45	Year	Area	Yield	Production				
46		(000 ha)	(kg/ha)	(000 mt)				
47	---	---	---	---	---	---	---	---
48	1979							
49	1980							
50	1981							
51	1982							
52	1983							

CALCULATING PRODUCTION

Move to the first table, Wetseason Palay, using the **[Home]** key. Move the cursor to the first row under the Production column (D8). Create a formula that shows area times yield. This number must be divided by 1,000 in order to convert kg. to thousand metric tons ('000 mt). If the production data remain in kg., the numbers are too large to comprehend easily. Policy-makers in the Philippines usually discuss palay production in terms of thousands of tons or millions of tons.

For cell D8,
Type: +
Move to: **B8** (area)

Type: *
Move to: **C8** (yield)
Type: **/1000**
Press: **[Enter]**

Production is now calculated as area times yield, converted to thousands of tons. The formula will be displayed above the worksheet on the screen.

Screen 3.2

```
D8: [W13] +B8*C8/1000000                                                READY

          A     B        C        D        E        F        G        H
 1|Philippine Food Crops Sector
 2
 3|Wetseason Palay
 4|
 5|Year        Area     Yield    Production
 6|            (000 ha) (kg/ha)  (000 mt)
 7|-----------------------------------------------------------------------
 8|   1979     3561     1615     5751.015
 9|   1980     3470     1629
10|   1981     3419     1674
11|   1982     351      1769
12|   1983     3054     1599
```

Copying a formula to another cell

Formulas that are entered with **relative cell addresses** can be copied easily to other cells. In the example above, the formula tells the cursor to move two cells to the left (area) and multiply that number by the number that is one cell to the left (yield). This can be copied for all of the cells in the production column. Unless directed otherwise by $ signs, the computer will adjust cell addresses so that their "relationship" on the worksheet is preserved.

Move to: **D8** (the formula under the production column for 1976)
Press: **/**
Select: ***Copy***
"Enter Range to Copy From: D8..D8"
Press: **[Enter]**

"Enter range to copy to: D8"
Move to: **D9**
Type a period: .
Move the cursor down to the end of the column.

172

Press: **[Enter]**

Production values for wetland palay will be calculated for all years.

Screen 3.3

D8: [W13] +B8*C8/1000000 READY

	A	B	C	D	E	F	G	H
1	Philippine Food Crop Sector							
2								
3	Wetseason Palay							
4								
5	Year	Area	Yield	Production				
6		(000 ha)	(kg/ha)	(000 mt)				
7								
8	1979	3561	1615	5751.015				
9	1980	3470	1629	5652.63				
10	1981	3419	1674	5723.406				
11	1982	3351	1769	5927.919				
12	1983	3054	1599	4883.346				
13	1984	3162	1783	5637.846				
14	1985	3306	1885	6231.81				
15	1986	3464	1913	6626.632				
16	1987	3256	1777	5785.912				
17	1988	3393	1878	6372.054				
18	1989	3497	1901	6647.797				

Use the ***Copy*** command to copy the production formula in each of the other tables for each of the other crops.

FORMATING PRODUCTION DATA

A previous exercise indicated how to format the numbers in the entire table using the ***/Worksheet Global Format*** command. Unless the spreadsheet was formatted previously, the values for the production calculations will have a large number of decimals. Format the production data so that the numbers have only two decimal places using the following steps.

Press: **[F5]** {Goto}
Press: **[Enter]**
Type: **D8**
Press: **/**
Select: ***Range***

Format
Fixed
2
[Enter]

"Enter range to format: D8 . . D8"

Move the cursor down until all of the numbers in the column are highlighted and press **[Enter]**. Format the production values for all crops. Once the tables are complete and formatted as desired, **save your file.**

CALCULATING GROSS REVENUE

Gross revenue for each crop and year is calculated by multiplying total production by the price. Data on prices for each crop are contained in Data Table 3.2 at the end of the Chapter. Begin by extending the tables to include prices and gross revenue, then enter the data on prices.

Press:	**[F5]** {Goto}
Type:	**E5**
Press:	**[Enter]**
Type:	**Price**
Press:	**[Right arrow]**
Type:	**Gross Revenue**

Expand the width of column F to 15 characters using the ***Worksheet Column Set-Width*** command.

Move to:	**E6**
Type:	**'(P/kg.)**
Press:	**[Right Arrow]**
Type:	**P mil**
Press:	**[Enter]**

Extend the line under the headings using the ***Copy*** command. (If you have forgotten how to do this, consult previous exercises or consult your Lotus 1-2-3 reference book.)

Copy the new part of the table to the tables for the other crops using the ***Copy*** command. The "Range to copy From" will be E5 . . F7. The "Range to copy To" will be one screen length below (E25 . .F27). Once the tables have been extended, save your worksheet.

Now enter prices into the tables using the data at the end of the Chapter. As with the area and yield data, it is easiest to enter each number and use the **[Down Arrow]** to move to the next cell. While entering the data, be aware of any irregularities or surprises in the numbers. Careful attention to the data while entering helps to identify errors in the reported figures and to identify interesting stories that come out of the data.

Gross revenue is production times price.

Move to:	**F8**
Type:	+
Move to:	**D8**
Type:	*
Move to:	**E8**
Press:	**[Enter]**

Copy the formula for the other years in the Wetseason palay table, then copy the formula for the other crops. Format the Gross Revenue data so that all of the numbers have 2 decimal places using the ***Range Format*** command.

Screen 3.4

F8: +D8*E8 READY

	A	B	C	D	E	F	G	H
1	Philippine Food Crops Sector							
2								
3	Wetseason Palay							
4								
5	Year	Area	Yield	Production	Price	Gross Revenue		
6		('000 ha)	(kg/ha)	(000 mt)	(P/kg)	(P mil)		
7								
8	1979	3561	1615	5751	1.01	5809		
9	1980	3470	1629	5653	1.15	6495		
10	1981	3419	1674	5723	1.32	7554		
11	1982	3351	1769	5928	1.39	8232		
12	1983	3054	1599	4883	1.55	7552		
13	1984	3162	1784	5638	2.51	14164		
14	1985	3306	1885	6232	3.26	20325		
15	1986	3464	1913	6627	2.85	18912		
16	1987	3256	1777	5786	3.06	17698		
17	1988	3393	1878	6372	3.41	21744		
18	1989	3497	1901	6648	4.19	27880		

CREATING RANGE NAMES

The ***Range Names*** command is a useful tool in organizing spreadsheets. After creating a range name, the table can be located by simply choosing that name. It is also useful in commands such as **Copying, Printing, Formatting, Moving,** and **Graphing.** Each of these requires a range specification. By naming the range of the table beforehand, it may then be used simply by invoking the name.

Begin by naming ranges to identify certain regions of the worksheet so that it becomes easy to move to specific tables.

Move to: **A3** (Wetseason Palay)

Press: /
Select: ***Range***
Name
Create
"Enter name:"
Type: **Wet-Palay**
[Enter]
"Enter range: A3 . . A3"

Move the cursor over the entire table for wetland palay so that it is fully highlighted and press **[Enter]**.

Create range names for the other crops.

Press: **[PgDn]** to move the cursor to Dryseason Palay.
Press: /
Select: ***Range***
Name
Create

Screen 3.5

```
A23:  'Dryseason Palay                                              FILES
Enter name:
WET-Palay
       A         B         C         D         E         F         G         H
═══════════════════════════════════════════════════════════════════════════
23|Dryseason Palay
24|
25|Year             Area      Yield     Production
26|                 (000 ha)  kg/ha        (000 mt)
27|---------------------------------------------------------------------------
```

Look at the third line of the panel below the worksheet. Below the prompt **Enter name:** you will see **WET-PALAY**. Each range name you create will now be listed when you select the **Range Name Create** command. When there are more names than fit the width of the panel, use the left and right arrow keys to see the complete list. The names will disappear when you type in a range name.

Type: **Dry-Palay**

Set the range to cover the entire table for Dryseason Palay and press **[Enter]**.

Follow the same directions to create range names for the tables on maize, and mungbeans. Once the range names have been completed, **save your worksheet.**

To see how the range names work, press **[Home]** to go to the top of the worksheet.

Press:	**[F5]** (GoTo)
"Enter address to go to:	A1"
Press:	**[F3]** (name) Note: Try pressing [F3] twice.
Select:	**Dry-Palay**
	[Enter]

The cursor will immediately jump to the table on dryland palay.

PRINTING TABLES

The *Print* command in Lotus 1-2-3 allows you to make hard copies of the spreadsheet. Because the spreadsheet on the Philippine Food Crops Sector data is much larger than a single page of paper, you must print individual sections of the worksheet at a time. The **Range Names** are useful in identifying sections of the worksheet (by crop) for printing. Before you start, make sure the printer is turned on and ready. Call up the Print menu.

Press: /
Print
Printer

The Printer sub-menu will appear in the panel above the spreadsheet.

Screen 3.6

```
A1: [W6] Philippine Food Crop Sector                                    MENU

Range    Line    Page    Options  Clear    Align    Go    Quit
Specify a range to print
        A         B         C         D         E         F         G         H
-------------------------------------------------------------------------------
 1|Philippine Food Crop Sector
 2|
 3|Wetseason Palay
 4|
```


177

The print menu offers a number of choices about the appearance and format of the printout. The only option that **must** be specified is the **range** to be printed.

Range	Specifies the range of the worksheet that will be printed. This **must** be specified even if you want to print the entire worksheet	
Line, page	Advances the paper one line or one page	
Options	Contains a number of choices about the appearance of the printout	
Header, Footer	Specifies header or footer to be printed on each page	
Margins	Sets left, right, top, and bottom margins	
Borders	Specifies border columns and/or rows	
Setup	Establishes printer setup string	
Page-length	Specifies number of lines per page	
Other	Print formulas on a worksheet or	Ignore print settings
Clear	Resets some or all of the print settings	
Align	Resets the alignment of the paper to the top of the page	
Go	Begins the printing process	
Quit	Returns 1-2-3 to the READY mode	

Specify the range of the worksheet you want to print using range names. From the menu,

Select:	***Range***
Press:	**[F3]**
Select:	**Wet-Palay**
	[Enter]

If the paper in your printer is properly aligned, and the printer is "on-line"

Select:	***Align***
	Go

The Wetseason Palay table will be printed out. Print the other tables using the respective range names. Between each table select ***Page*** from the menu in order to have each table printed on a separate page.

Data Table 3.1: Philippine Area and Yield Data

Philippine Food Crops Sector

AREA ('000 ha)

Year	Wetseason Palay	Dryseason Palay	Maize	Mungbeans
1979	3561	490	3090	31.5
1980	3470	532	3199	33.5
1981	3419	568	3295	34.0
1982	3351	602	3383	35.4
1983	3054	618	3132	33.6
1984	3162	576	3227	33.8
1985	3306	643	3511	35.5
1986	3464	680	3595	36.0
1987	3256	689	3683	34.7
1988	3393	658	3745	36.7
1989	3497	702	3689	35.7

YIELD (kg/ha)

Year	Wetseason Palay	Dryseason Palay	Maize	Mungbeans
1979	1615	3600	950	696
1980	1629	3750	954	737
1981	1674	3850	1000	744
1982	1769	4000	1006	740
1983	1599	3900	1001	741
1984	1783	3800	1007	743
1985	1885	4000	1100	713
1986	1913	3850	1138	719
1987	1777	4000	1162	729
1988	1878	3950	1182	725
1989	1901	4000	1226	703

Data Table 3.2: Philippine Price Data

Philippine Food Crops Sector

PRICE (P/kg)

Year	Wetseason Palay	Dryseason Palay	Maize	Soybeans
1979	1.01	1.01	0.92	7.84
1980	1.15	1.15	1.06	8.06
1981	1.32	1.32	1.21	9.96
1982	1.39	1.39	1.28	6.47
1983	1.55	1.55	1.38	6.36
1984	2.51	2.51	2.37	10.73
1985	3.26	3.26	2.79	11.98
1986	2.85	2.85	2.51	12.41
1987	3.06	3.06	2.85	10.69
1988	3.41	3.41	2.84	11.91
1989	4.19	4.19	3.84	15.01

CHAPTER 4: DISAGGREGATING AGRICULTURAL SECTOR DATA

Chapter 3 was devoted to the creation of a database. The estimates in that chapter are aggregated to the national level. Such aggregation obscures differences due to seasonality, agroclimatic zones, and production technologies. Understanding the regional impact of national policies on income and production requires a greater degree of disaggregation. Chapter 4 contains exercises that disaggregate wetland palay production in the Philippines by land type. The data are classified into 4 land types, defined by soil conditions, fertility, and water control. Each land type has a different cropping intensity (number of crops per year), input use, and level of profitability. The 4 land types are:

1) high productivity irrigated land,
2) medium productivity irrigated land,
3) low productivity irrigated land, and
4) rainfed land

The main substantive objective of the exercise is to calculate the contribution of each land type to total production of wetland palay and to show how the relative contributions have changed over a 13 year period. The results will then be graphed using stacked bar graphs. These results provide further insight into the characteristics of the food crops sector by demonstrating the source of output growth by land type.

The exercise offers an opportunity to practice a variety of Lotus commands, especially those used to copy formulas and tables.

COMPUTING REGIONAL PRODUCTION ESTIMATES

The figures in Data Table 4.1 (p. 35) describe the area and yield of wetland palay in each of the four land type systems for 4 observation years: 1976, 1980, 1986, and 1989. The data in this table will be used to calculate the total area in each land system and the contribution of each system to total production over time.

Begin by creating a Lotus 1-2-3 table that resembles Data Table 4.1. Enter the dates as labels using a label prefix. Enter the production systems based on land types as rows. Enter the estimates of area and yield and columns.

Calculating Production and Production Shares in Each System

Once the table has been created, area and yield can be multipled to give an estimate of production. This could easily be done on the existing worksheet. However, for practice, **copy** the initial table to a position one screen **[PgDn]** below and compute aggregate regional production and regional shares in the second table.

To copy the data table format from the first table to the second (calculations) table:

Move to the top of the first table.

Data Table 4.1. Area and Yield of Wetseason Palay by Land Type

Wetseason Palay	Area by Land Type ('000 ha)				Yield (ton/ha)			
Land Type	1976	1980	1986	1989	1976	1979	1983	1989
High Productivity (Irrigated)	246	283	316	340	3.75	4.25	4.50	5.05
Medium Productivity (Irrigated)	278	320	356	384	2.75	3.40	3.75	3.95
Low Productivity (Irrigated)	313	360	402	433	1.95	2.75	3.15	3.10
Rainfed	2813	2508	2390	2340	0.90	0.95	1.10	0.90
Total Wetseason								

Press: */Copy*

Enter a range which highlights the entire table.

Press: **[Enter]**
Move one page down using the **[PgDn]** key.
Press: **[Enter]**

Move to the new table and erase the contents of the table using the ***Range Erase*** command.[4]

In the new table, type new headings: **Wetseason Palay Production By Land Type.**

Calculating Wetseasons Production

Move to the row and column in the new table reserved for *high productivity irrigated agriculture*. Enter the formula in that cell to calculate production by multiplying acreage times yield using the cell addresses in the first table. Using the ***Copy*** command, copy the formula into the cells for the entire "Production" block. That is, instead of copying each column independently, simply **highlight the columns for all three years at once.** All cell relationships will be preserved

[4] It is not actually necessary to erase numerical values if these are to be replaced with other numerical values. Lotus will simply write over the existing data.

and the entire "Production" block can be copied at one time.

Using the ***Copy*** command in this fashion will produce 0's where blanks occur in the table. Suppress the 0's with the */Worksheet Global Zero Yes* command (/WGZY)

/WGZY

(Note that this command does not actually remove the 0's; they will reappear each time the worksheet is retrieved. If the formulas that generate the 0's are to be removed completely, use the ***Range Erase*** command.)

Once production has been calculated for the individual land types for each year, you can add the production figures using the ***@SUM*** command to arrive at the total production of wetland palay by year. (See Box 4.1.)

Move to the last row, "Total "
Move to the column for 1976.
Type: **@SUM(**
Move to the top of the column, "High Productivity Irrigated".
Anchor the range by typing a period: .
Move to the last row, "Rainfed."
Type:)
Press: **[Enter]**.
Copy to remaining columns.

Calculating the Share of Production (Percentage) by Land Type.

In order to calculate the share of production by land type, replace the original table's "Yield" block with a "Share" block in the new table.

Replace the word "Yield" with "Share of Production." (Erase the (ton/ha) cell.)

Move to the row and column describing "High Productivity" and "1976" under the "Share" section

Lotus Functions

An @ function is made up of three parts:

(1) The @ symbol, which must appear as the first character.
(2) The name of the function
(3) The data to which the function is to be applied. The data can be a single cell or a range of cells.

The data can be addressed by *relative cell addresses* or by *range names*. Example:

@SUM(B20 . . B28) indicates that the values in rows 20 through 28 in column B should be added together. Other functions include:

@IRR()internal rate of return
@NPV() net present value
@AVG() average
@MAX() maximum value

(The Lotus manual or any Lotus book will display and define all of the function commands. They will be described in this manual when they are used.)

Box 4.1

Enter the formula to calculate the share of production. The basic formula is: **production in 1976 divided by total production**. Use an **absolute** cell address (a dollar sign) to compute the production row so that, when the ***Copy*** command is used, the columns will change but the row will remain the same. For example, the formula in the upper left hand corner of the table's data block might look as follows:

Screen 4.2

Wetseason Palay Production by Land Type

Land Type	Production '000 mt 1976	1980	1986	1989	Share of Production 1976	1980	1986	1989
High Productivity (Irrigated)	923	1202	1421	1718	18.9%	21.2%	21.4%	25.9%
Medium Productivity (Irrigated)	764	1086	1337	1517	15.7%	19.2%	20.2%	22.8%
Low Productivity (Irrigated)	615	983	1269	1335	12.6%	17.4%	19.1%	20.1%
Rainfed	2572	2385	2607	2075	52.8	42.2%	39.3%	31.2%
Total Wetseason	4873	5657	6634	6645	100%	100%	100%	100%

+B27/B$37 [5]

The formulas for all of the other data cells in the block can be computed with a single step. When the ***Copy*** command prompts with "COPY TO", move the cursor to the lower right hand corner of the table's data section. When the entire data block has been highlighted, press **[Enter]**.

The original calculation will produce values with a large number of decimals. These can be altered and percent signs can be introduced by formatting with the ***Range Format*** command. Decimal places can be set with the same command.

GRAPHING REGIONAL PRODUCTION STATISTICS

Move to the previous table on production of wetland palay production by land type. Graph the changes in production shares and total production over time with a stacked bar graph.

Select ***Graph*** from the main menu. Use the cursor and highlights to enter the type of graph, i.e., stacked bar. Select X for the range of the independent variable. (Use the ESC key to erase previous ranges should these show up in a block on the screen.) Position the cursor on the first cell in the range, "anchor" with a period, and highlight the entire range. Press **[Enter]**.

[5] Your row and column addresses may, of course, be slightly different. In this example, cell B27 contains a formula that multiplies yield times acreage under high productivity palay for 1976. Cell B37 totals the rice produced in all systems during that year.

Choose A for the range or row that describes the value of production in each year from high productivity irrigated land. Position the cursor on the first cell in the range, anchor with a period, and highlight the entire range. Press **[Enter]**.

Follow the same procedure for the remaining data series. When the data entry is complete, select **View** for a screen rendition of the graphed data without any titles or legends. The choices associated with each range are indicated below.

Type	stacked bar
X	range containing dates, 1976, 1980, 1986, 1989.
A	row of values for high productivity irrigated land.
B	row of values for medium productivity irrigated land.
C	row of values for low productivity irrigated land.
D	row of values for rainfed land.

When the data have been entered and verified, add titles and legends to the graph.

Select:	***Options***
Select	***Titles***
First:	**Wetseason Palay Production**
Second:	**By Land Type**
X:	**Year**
Y:	**Metric tons**
Select:	***Quit***
Select:	***View***

The graph should look approximately like the one in Figure 4.1. (Legends can be created using the **Options** menu.) If the appearance of the graph is satisfactory, **save the graph file**. Lotus then prepares a file for printing. Note: to avoid confusion in the titling of units of measure along the Y-axis, you may convert the rows of production values into metric ton units (i.e., multiply by 1000) to have Lotus print "(millions)" instead of "(thousands)" along the Y-axis and beneath your Y-axis title.

Save the worksheet containing the graph with /File Save Replace. (Failure to save the **worksheet** as well as the **graph** will result in losing the graph that is viewed from the worksheet. The work of assigning ranges, titles and legends will be lost.)

Exit 1-2-3 with /Worksheet Quit Yes (/WQY) to move to the menu displaying the PrintGraph program. Enter the PrintGraph program by pressing **[Enter]**. When in the PrintGraph part of Lotus:

Select:	***Image-select***
Move the cursor to the name of the file saved before exiting Lotus 1-2-3.	
Press:	**[Enter]**
Select:	***Go***

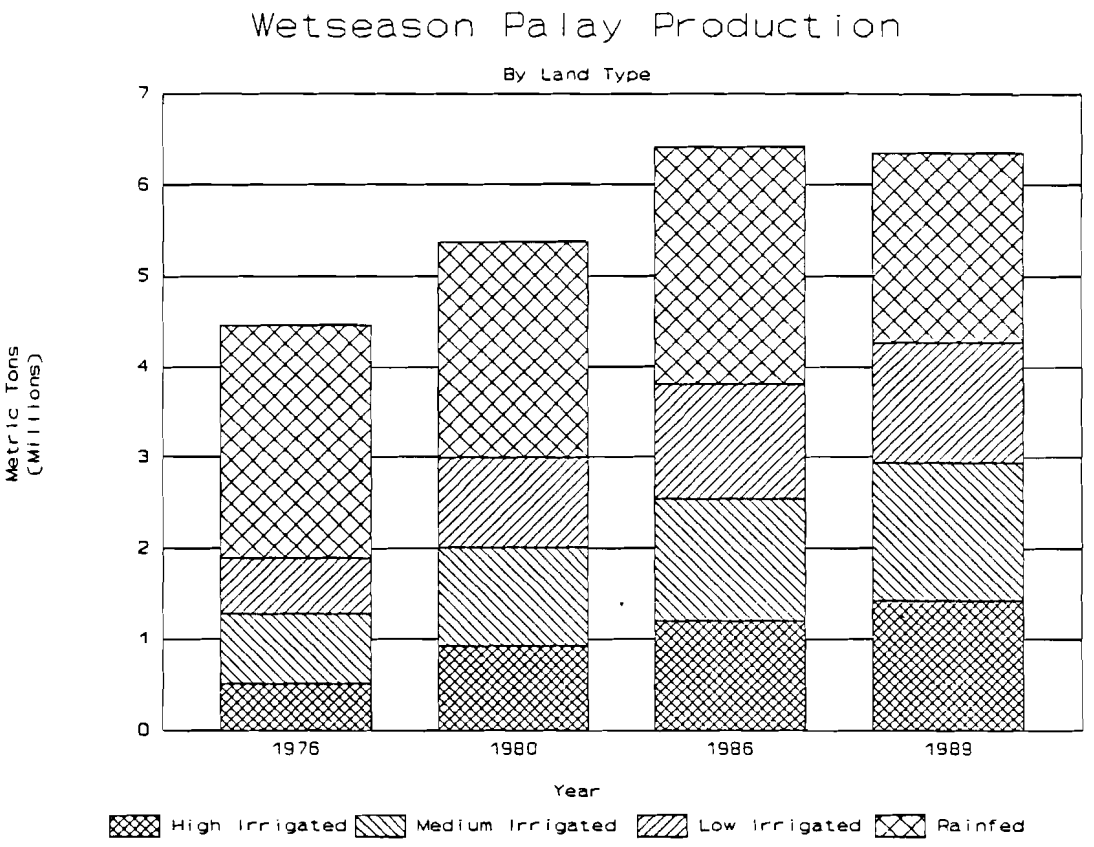


Figure 4.1

A second, equally interesting stacked bar chart can be developed using the share calculations. The resulting stacks sum to 100; they provide evidence on what has happened to the distribution of production across types of production systems. Such graphs are a good first step in identifying the sources of growth and the incidence of technical change.

BEST AVAILABLE COPY

CHAPTER 5: COMPUTING STATISTICAL MEASURES AND TRENDS

Data on the production of various food crops, calculated in the previous exercise, provide important information on the food crops sector in Philippines. But time series data, to be really helpful, need to be summarized. For example, information about a particular year increases in value if it can be related to the **average** over the recent past. The **highest** and the **lowest** values in the series also provide additional points of reference. Still more information can be obtained from a particular annual figure if it can be related to **trends** in the data over time.

The following exercise begins by demonstrating how Lotus functions can be used to compute parameters such as the mean, variance, maximum and minimum of a time series. The spreadsheet's built-in regression capability is then used to compute a trend. Subsequently, the data and the trend are plotted on the same graph, a procedure that allows the analyst to add a visual assessment of the goodness of fit to the standard errors report by the regression program.

COMPUTING SUMMARY MEASURES

Call up the worksheet containing data on the Philippine Food Crop sector, */FR*.

Screen 5.1

Wetseason Palay Trends

Year	Area 000 ha	Yield kg/ha	Production 000 mt	Price P/kg	Revenue P mil	ProTrend
79	3561	1615	5751	1.01	5809	5463
80	3470	1629	5653	1.15	6495	5557
81	3419	1674	5723	1.32	7554	5650
82	3351	1769	5928	1.39	8232	5744
83	3054	1599	4883	1.55	7552	5837
84	3162	1783	5638	2.51	14164	5931
85	3306	1885	6232	3.26	20325	6025
86	3464	1913	6627	2.85	18912	6118
87	3256	1777	5786	3.06	17698	6212
88	3393	1878	6372	3.41	21744	6305
89	3497	1901	6648	4.19	27880	6399
Average	3358	1766	5931	2.34	14215	
Variance	21182	13175	240157	1.09	51796898	
Maximum	3561	1913	6648	4.19	27880	
Minimum	3054	1599	4883	1.01	5809	

Screen 5.1 shows a table containing data on production and gross revenues for wetland rice palay. The summary measures have been computed using Lotus functions.

The extended statistical functions are used in exactly the same way as the @SUM function. The mean or average is calculated using @AVG; the variance is computed with @VAR. Maximum and minimum are obtained by using @MAX and @MIN.

After typing in the function name, set the range over which the analysis is to be carried out. For example: @AVG(D8..D18)

REGRESSION ANALYSIS FOR TREND CALCULATIONS

A **trend** shows the estimated least squares relationship between the observed data and time. It is calculated by ordinary least squares regression with time as the independent variable (x-axis) and production or revenue as the dependent variable (y-axis). The following illustration shows production trends for wetland palay in thhe Philippines from 1979 to 1989.

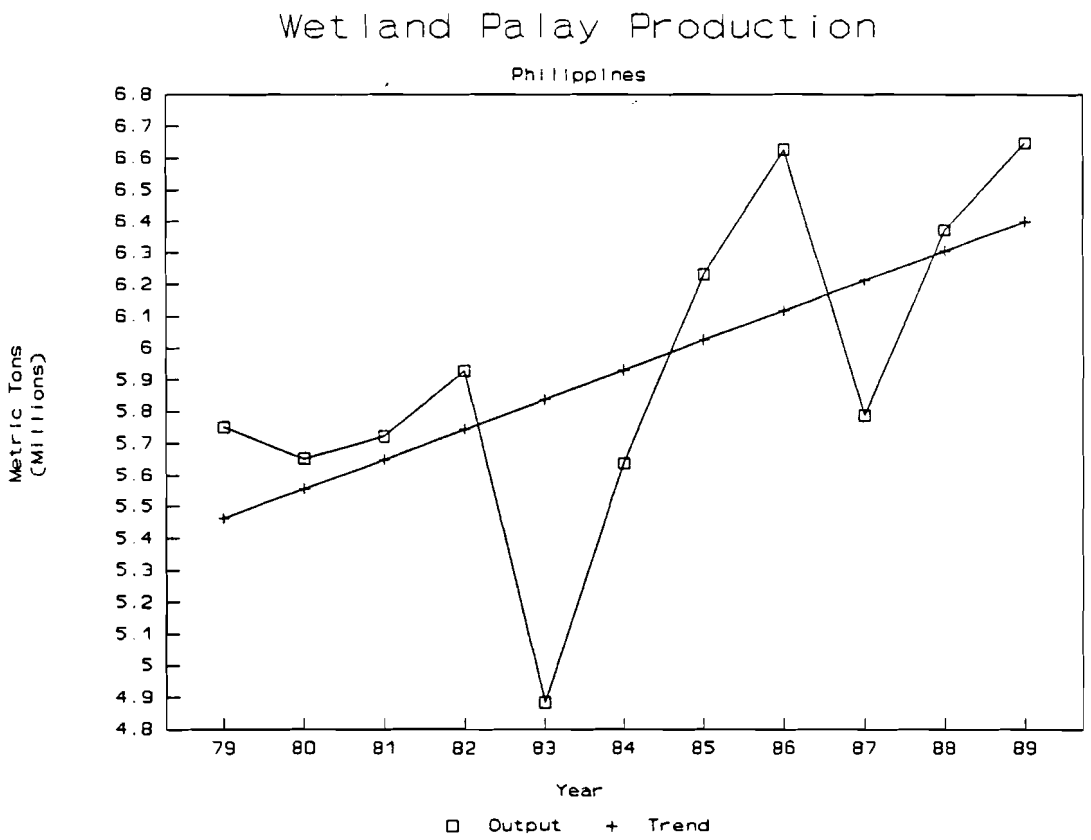


Figure 5.1

The following exercise describes the steps needed to produce such a graph.

Regression Command in Lotus

Regressions are performed in Lotus with the **Data Regression** command. In order to run a regression the following must be specified:

X-Range	The data range containing the independent variable. When calculating trends, the series consists of years. (If a substantial number of data points exist, it is usually a good idea to use only two numbers to indicate years, e.g., 1980 becomes simply 80, in order to avoid overlapping labels on the X-axis.) The entries for dates in a regression must be values not labels.
Y-Range	The data range containing the dependent variable. In the following exercise, the dependent variable will be **production** for each crop. (When specifying the Y-range, the column of data must contain the same number of rows specified for the X-range.)
Output-Range	Specifies the range of cells that will receive the output of the regression. The output range must be at least nine rows deep and two columns wider than the number of independent variables but not less than four columns. In calculating trends, the range must be 9 rows deep and 4 columns wide.
Intercept	Two choices are possible: Compute or Zero. Zero forces the y-intercept to be zero. Compute (the default) permits a non-zero intercept.

A regression is performed by using the command **Go** from the regression menu. Lotus 1-2-3 will perform the analysis and display the following information in the output range:

Constant	The Y-intercept
Std Err of Y Estimate	Standard error of the estimated Y values
R-Squared	One measure of "goodness of fit"
No. of Observations	Number of values for the X and Y variables
Degrees of freedom	Number of observations relative to the number of dependent variables
X Coefficient(s)	Slope for each of the independent variables
Std Err of Coef.	Standard error for each of the X Coefficients

Running a Regression

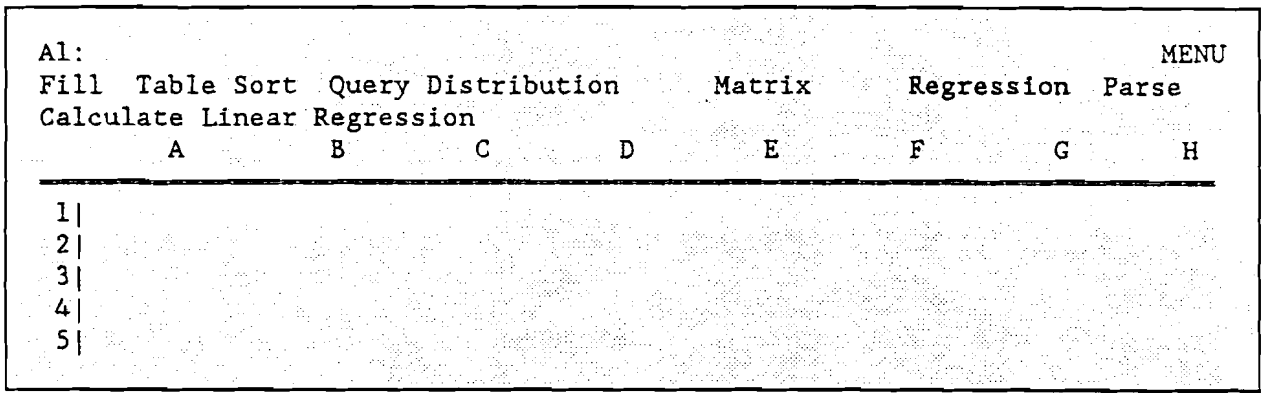
Before specifying the parameters for the regression, change the dates in the table so that each year has 2 characters (e.g., change 1979 to 79). This will permit the data to be used as labels on the x-axis without overcrowding.

The quickest way to produce a series in Lotus 1-2-3 is to use the */Data Fill* command. The menu asks for a starting value. Use 79 for 1979. Highlight 11 rows in the same column in response to the question: Data range. End the series with 89 and tell Lotus to use a step value of 1. **The years must be specified as values** in order to run a regression with years as the independent variable. Then:

Press: /
Select: *Data*

A sub-menu will appear.

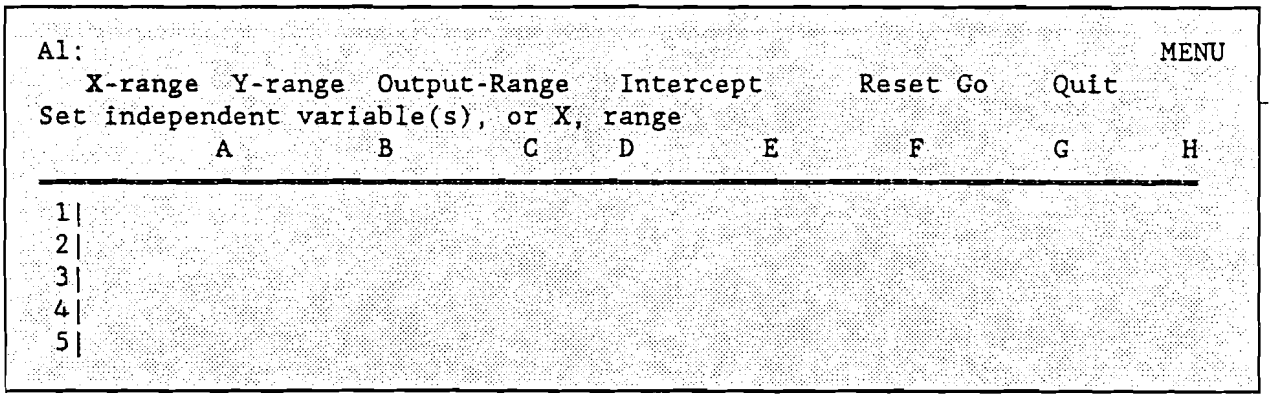
Screen 5.2



Select: *Regression*
Select: *X-range*

The initial element of the range is the first year, i.e., 79. The last year is 89.

Screen 5.3



Press: **[Enter]**
Select: *Y-range*

Production is the dependent variable over the same vertical range.
Select: *Output-range*

Put the output range (regression results) to the right of the data table.

Select:	*Intercept*
	Compute
Select:	*Go*

The regression will be performed and the output will appear beginning with the cell selected to receive the results. The important values for the trend calculation are (1) the **constant**, and (2) the **coefficient** associated with the independent variable. These numbers will be required in computing the trend values for each year. Lotus will display the following output block:

Regression Output:	
Constant	-1932.16
Std Err of Y Est	431.7701
R Squared	0.364872
No. of Observations	11
Degrees of Freedom	9
X Coefficient(s)	93.60909
Std Err of Coef.	41.16766

COMPUTING TREND VALUES FOR AGRICULTURAL PRODUCTION

The results of the regression analysis can be used to calculate trends with the formula $Y = a + bX$ where:

Y = production or revenue
a = constant (intercept)
b = x coefficient (for years)
X = years

To compute the values that will be needed to plot the trend on the same graph as the production data, both **relative** and **absolute** cell addresses will be needed.
Remember that in order to copy a formula in which the same cell is to be addressed for all rows and columns, a $ sign must be inserted in front of the row and column address. In the trend calculation, you will want to fix both the row and the column for the **constant** (e.g., $R$9) and for the **coefficient** of the independent variable, time (e.g., $Q$15). The F4 function key can be used to create an absolute cell address. The necessary steps are shown below.

To compute: $Y = a + bX$

Move to:	**ProTrend**	(First blank cell of the ProTrend column)
Type:	+	
Move to address for:	**Constant**	(Value in the regression output block)
Press:	**[F4]**	(Absolute cell address. You will see the dollar sign added to the cell address in the panel above the worksheet.)
Type:	+	
Move to address for:	**Year**	Year will be a **relative** cell address
Type:	*	
Move to address for:	**X-coefficient**	(Coefficient value in the regression output block)

Press:	**[F4]**	Absolute cell address
Press:	**[Enter]**	

The calculation will appear in the first row of the production trend column. Since you have done the calculation using **absolute** cell addresses, you can copy the formula to the remaining cells in the production column using the *Copy* command.

GRAPHING PRODUCTION TRENDS

In order to graph production trends, begin by creating the graph in Lotus 1-2-3. For clarity in the presentation of production numbers along the Y-axis, convert first the production values into metric ton units by multiplying each of the numbers in the cells D8..D18 by 1000. Do the same for the numbers under the column **production trend**. These two new data series should now be in cells H8..H18 and I8..I18, respectively. After these conversions, proceed with the following steps.

Press:	/
Select	***Graph***
	Type
	Line
	X

The X range indicates the values on the X-axis of the graph. In this exercise, production numbers and the trend will be graphed against time, so **Years** will be on the X-axis.
Enter the range corresponding to the years in the table.

Select: ***A***
"Enter first data range:"
The first data range contains the production **numbers** in cells: H8..H18.

Select: ***B***
"Enter second data range:"

The second data range contains the computed values for the **production trend** in the column **ProTrend** (Cells I8..I18)

Select:	***Options***
	Legend
	A

"Enter legend for first data:"
Type: **Output**

Select:	***Legend***
	B

Type: **Trend**

Select: ***Titles***

Enter the following titles:

First:	Wetseason Palay Production
Second:	Philippines
X-axis:	Year
Y-axis:	MMT

Select: ***Quit***

Once you have specified the graph, you can view it by selecting ***View***. Press [Esc] to return to the graph menu.

Before you leave the graph command, save it for printing.

Select: ***Save***
Type: **Wet-Pal**

The graph will be saved as WET-PAL.PIC.

PRINTING THE GRAPH

Select: ***Quit***
The program menu of Lotus will appear on the screen.
Select: ***PrintGraph***
The graphics menu will appear.

Screen 5.4

```
Copyright 1986, Lotus Development Corp. All Rights Reserved. Release
2.01.
--------------------------------------------------------------------------
Select graphs for printing

Image-Select    Settings    Go    Align    Page    Exit
```

Select: ***Image-Select***

A list of existing graphics files will appear on the screen. Select the graph to be printed.

Move the cursor to **Wet-Pal** and press **[Enter]**.

Make sure that your printer is turned on and that the paper is aligned.

Select: ***Go***

The graph of wetland palay production and the trend shown in Figure 5.1 will be printed.

Use the same series of commands to calculate and graph price and revenue trends. What conclusions can you draw from these graphs? Would you be confident in making predictions about the general health of the rice production sector on the basis of these data?

COMPUTING A GROWTH RATE

Having the trend line appear on the same graph as the original time series helps interpret the results of the regression equation. It can also be used to provide an estimate of the growth rate that provides a more reliable indicator of performance than if growth was computed from the end points of the series.

Growth rates are conventionally calculated at the mean or average of the series. The formula therefore is simply the slope (the coefficient of the independent variable, X, computed by the regression) divided by the mean of the dependent variable, Y.

To estimate the growth rate of production for wetland palay, enter the following formula in a convenient empty cell:

Cell address of coefficient of X / cell address of @AVG (production)

As noted above, the coefficient of X is the slope coefficient displayed in the regression output. The Lotus @AVG function automatically finds the mean of the dependent variable Y, in this case PRODUCTION. The result of this calculation may be formatted as a percent by using the **Range Format Percent** command.

CHAPTER 6: ANALYZING AGGREGATE OUTPUT

In Chapter 5, trend analysis was used to gain insights into the behavior of a single commodity over time. In the following exercise, it is extended to compute a measure for growth in the agricultural sector as a whole. The data required are the annual estimates of gross revenues that have already been calculated for individual crops in Chapter 3.

TRENDS IN THE VALUE OF AGRICULTURAL OUTPUT

To compute the graph shown in Figure 6.1, retrieve the worksheet containing the data for the Philippine Food Sector. Find an area below the last crop table and create the following table:

Year	Gross Revenue
76	(f8 + f28 + f48 + f68)
...	...
86	(f18 + f38 + f58 + f78)

Use the ***Data Fill*** command to create the series: 1976 - 1986. Use the ***Copy*** command to copy the formula for gross revenue at current prices down the column. (Note: Your cell addresses may be slightly different as a result of differences in the number of lines that separate the individual commodity tables.)

Compute the trend line of gross revenue at current prices using the methods described in Chapter 5. Calculate the growth rate also. Your answer should be roughly 16 percent per annum. Note that both the graph and the growth rate bear a good deal of similarity to the graph of wetland palay shown in Chapter 5. This is because wetland palay has such a large weight in the output of Philippines's agricultural sector. Note also that a growth rate computed as the difference between the first year and the last divided by the mean is 15.5 percent per year.

For most purposes, graphs based on current prices are less useful than graphs using constant price weights. The physical performance of the agricultural sector is of primary interest, not the extent of commodity price inflation.

The values for constant prices shown in Figure 6.1 were computed using 1989 weights. (Ordinarily, growth rates in constant prices are not terribly sensitive to the choice of base year weights. But if there have been substantial changes in relative prices as a result of significant policy interventions, care needs to be taken in drawing conclusions based on a particular period.) Using the same prices for all years and thus restricting increases in the value of output to increases in physical output obviously has a significant impact on estimates of growth in the value of agricultural output. For example, the growth rate declines from roughly 16 percent per annum to 3 percent per annum.

Still another improvement in aggregate data analysis could be obtained if costs were subtracted from revenues. The figures shown in the table clearly give an inflated picture of

agriculture's contribution to the economy since they do not account for the inputs required to produce the crops. The tables computed earlier could be extended horizontally and values entered for such inputs as fertilizer, pesticide, seeds, etc. The result would be a measure of agriculture's value-added, i.e., its contribution to gross domestic product. Trends in value-added could then be computed using the methods used above.

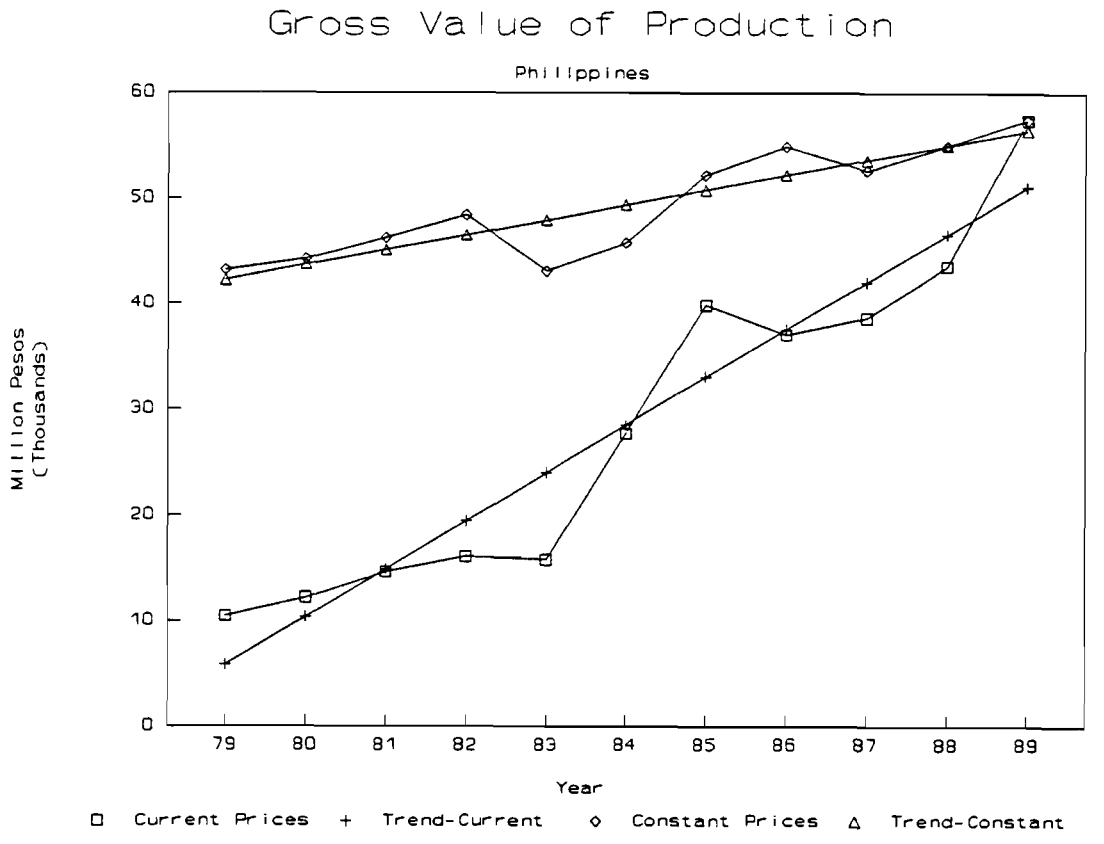


Figure 6.1

DECOMPOSING AGGREGATE OUTPUT

Computing trends in aggregate output provides important insights into the overall performance of the agricultural sector. However, it is equally interesting to decompose the sector's performance into changes in area, cropping patterns, and yields. Trend values cannot be used for this purpose; there is nothing to insure that independently measured values for acreage, yields and crop share would result in the trend value for gross revenue. Decomposition must therefore be done using the actual end periods of the series. (If the first and last periods lie far from the trend line, it may be desirable to take an average of the last several periods at each end so that the decomposition is not biased by extreme end points.)

The identity used to decompose changes in gross revenue from the beginning to the end of the period is given below. The first term on the right hand side captures the effect of increasing area if yields and the compostion of the cropping pattern had remained the same. The second term reflects the changes in yields over the period, other things being held constant. The third term captures the effects of changes in crop compostion, and the last term computes the interactions between changes in the various components of growth.

$$
\begin{aligned}
(R_t - R_o) \equiv\ & (A_t - A_o) \sum_{i=1}^{n} p_i Y_{io} C_{io} \\
& + A_o \sum_{i=1}^{n} p_i (Y_{it} - Y_{ot}) C_{io} \\
& + A_o \sum_{i=1}^{n} p_i Y_{io} (C_{it} - C_{io}) \\
& + \sum_{i=1}^{n} p_i (A_t - A_o)\ (Y_t - Y_o)\ (C_t - C_o)
\end{aligned}
$$

where R = Revenue, A = acres, Y = yields, C = percent of cropped acreage, and p = constant price weights.

The values needed for the decompositon exercise can be computed from the tables that were created in the previous exercises. Start the exercise by retrieving the Philippine Food Sector worksheet containing the various commodity tables. (This worksheet was also used in the preceding exercise.) Find a blank spot below the last table on the worksheet and lay out the table shown below:

Decompostion of Output

	Wetseason	Dryseason	Maize	Mungbeans	Total
Area					
1979	3561	490	3090	31.5	7172.5
1989	3497	702	3689	35.7	7923.7
Change	-64	212	599	4.2	751.2
Yields					
1979	1615	3600	950	696	
1989	1901	4000	1226	703	
Change	286	400	276	7	

Shares

1979	0.496	0.068	0.431	0.004	1.000
1989	0.441	0.089	0.466	0.004	1.000
Change	-0.055	0.020	0.035	0.000	0
1989 Prices	4.19	4.19	3.84	15.01	

Values for area and yields can be obtained either by typing in the data directly or by referencing the appropriate cell addresses of the commodity tables. The entries in the section entitled **Shares** are obtained by dividing the commodity acreage shown in the **Area** section by the total acreage of all commodities shown under the **Total** column.

The table below shows values for the various terms of the decomposition identity. For example, as the first term of the identity shows, the contribution of **area changes** to the increase in the value of wetland rice output is:

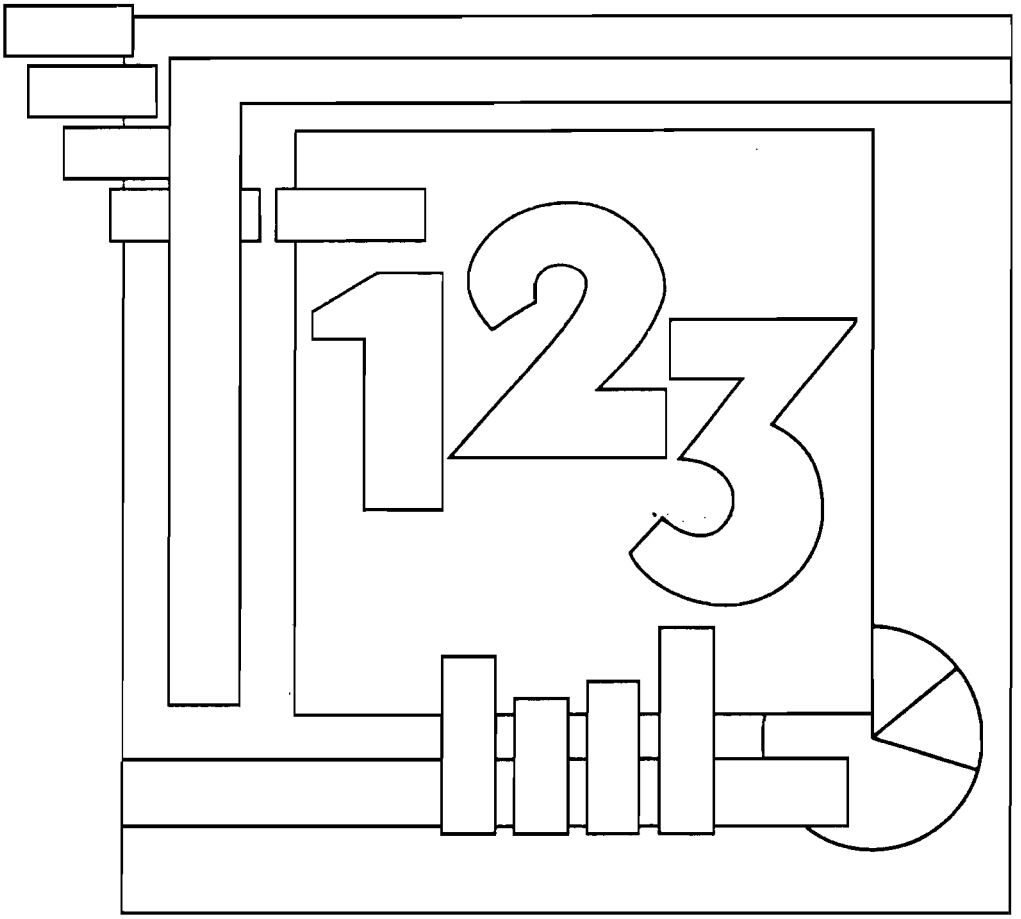
(change in area) x (base year yield) x (base year share) x (1989 price)

	Wetseason	Dryseason	Maize	Mungbeans	Total	Percent
Area	-215226	218664	942119	193	945750	25.0%
Yield	2121595	56156	1410909	14	3588675	94.9%
Pattern	-1330128	150019	392053	37	-788019	-20.8%
Interaction	4235	7212	22063	0	33511	0.9%
Value	580477	432051	2767145	245	3779916	100.0%

The results of the decomposition exercise suggest that roughly 79 percent of the resultant increase (94.9% / (25.0% + 94.9% + 0.9%)) in the value of agricultural revenues came from yield effects. These effects are due, in large measure, to the adoption of the high-yielding production technology for rice, i.e., modern seeds, fertilizer, irrigation, pesticides. Another 21 percent was due to an area effect that mostly worked through an expansion of corn areas and irrigated palay in the dry season. From a policy perspective, sustaining this type of growth means that attention needs to be paid to input prices, agricultural research, irrigation, etc.

Lotus 1-2-3 Release 2.2

Quick Reference



About *Quick Reference*

Quick Reference summarizes Lotus® 1-2-3® Release 2.2 keys, file extensions, label prefixes, arithmetic and logical operators, @ functions, and macro commands. It also contains the "Task Reference," which describes common Release 2.2 tasks and lists the commands you use to complete them, and menu trees for main menu commands in 1-2-3, Allways™, PrintGraph, and Macro Library Manager.

Quick Reference is designed for people who are already familiar with Release 2.2 and need to refresh their memory about a specific detail such as what keys to use to edit an entry or what the argument is for a particular @ function. The "Task Reference," located later in this book, is designed to help you match a specific task with its Release 2.2 command.

Quick Reference provides a summary of specific topics. For other types of information about 1-2-3 or the utility and add-in programs that are provided with 1-2-3, refer to the Release 2.2 documentation described in the following table.

Manual	Description
Setting Up 1-2-3	Complete instructions for installing 1-2-3 and the Allways add-in
Tutorial	A step-by-step tutorial that teaches basic 1-2-3 tasks through structured, progressive lessons
Quick Start	An overview of 1-2-3 concepts and basic skills for intermediate and advanced computer users who want to begin their own work quickly
Sample Applications	Specific examples of using 1-2-3 to manage and analyze data, and solve problems
Reference	A comprehensive guide to 1-2-3 commands and features; and to the utility and add-in programs that are provided with 1-2-3
Chapter 1 of *Reference*	A complete description of 1-2-3 concepts and basic skills
Appendix F of *Reference*	Solutions for common 1-2-3 problems
Upgrader's Handbook	New feature and compatibility information for users who are upgrading from a different release of 1-2-3

1-2-3 Keys

The following tables briefly describe some of the groups of keys you can use in 1-2-3: keys for moving around the worksheet, editing keys, and function keys. For detailed descriptions of all the keys you can use in 1-2-3, see Chapter 1 of *Reference*.

Keys for Moving Around the Worksheet

Name	Description
←	Moves cell pointer left one column.
→	Moves cell pointer right one column.
↓	Moves cell pointer down one row.
↑	Moves cell pointer up one row.
BACKTAB (SHIFT-TAB)	Moves cell pointer left one screen.
BIG LEFT (CTRL-←)	Moves cell pointer left one screen.
BIG RIGHT (CTRL-→)	Moves cell pointer right one screen.
END ←	Moves cell pointer left to intersection of a blank and a nonblank cell.
END →	Moves cell pointer right to intersection of a blank and a nonblank cell.
END ↑	Moves cell pointer up to intersection of a blank and a nonblank cell.
END ↓	Moves cell pointer down to intersection of a blank and a nonblank cell.
END HOME	Moves cell pointer to lower right corner of active area.
HOME	Moves cell pointer to cell A1.
PGDN	Moves cell pointer down one screen.
PGUP	Moves cell pointer up one screen.
TAB	Moves cell pointer right one screen.

Editing Keys

Name	Description
→	Moves cursor right one character.
←	Moves cursor left one character.
↑	Completes editing and moves cell pointer up one row.
↓	Completes editing and moves cell pointer down one row.
BACKSPACE	Erases character to left of cursor.
CTRL-→ or TAB	Moves cursor right five characters.
CTRL-← or SHIFT-TAB	Moves cursor left five characters.
DEL	Erases current character.
END	Moves to last character in entry.
ENTER	Completes editing.

(Continued)

Name	Description
ESC	Erases all characters in entry.
HOME	Moves to first character in entry.
INS	Switches between inserting text by moving existing text to right (INS mode), and writing over existing text (OVR mode).
PGUP	Completes editing and moves cell pointer up one screen.
PGDN	Completes editing and moves cell pointer down one screen.

Function Keys

Name	Description
ABS (F4)	**POINT and EDIT modes:** Cycles a cell or range address between relative, absolute, and mixed.
APP1 (ALT-F7)	**READY mode:** Activates add-in program assigned to key, if any.
APP2 (ALT-F8)	**READY mode:** Activates add-in program assigned to key, if any.
APP3 (ALT-F9)	**READY mode:** Activates add-in program assigned to key, if any.
APP4 (ALT-F10)	**READY mode:** If no add-in program is assigned to key, displays the Add-In menu. Otherwise, activates add-in assigned to key.
CALC (F9)	**READY mode:** Recalculates all formulas in worksheet. **VALUE and EDIT modes:** Converts a formula to its current value.
COMPOSE (ALT-F1)	**READY, EDIT, and LABEL modes:** When used in combination with alphanumeric keys, creates international characters and other characters you cannot enter directly from keyboard. For a list of compose sequences, see Appendix A.
EDIT (F2)	**READY mode:** Puts 1-2-3 in EDIT mode and displays contents of the current cell in control panel, so you can edit entry. **EDIT mode:** Switches between EDIT mode and LABEL mode, if entry displayed in control panel is a label, or VALUE mode, if entry displayed in control panel is a value.
GOTO (F5)	**READY mode:** Moves cell pointer directly to cell or named range you specify.
GRAPH (F10)	**READY mode:** Displays current graph.
HELP (F1)	Displays a 1-2-3 Help screen related to task you are performing. **HELP mode:** Displays first Help screen you viewed. **ERROR mode:** Displays a Help screen that explains error message 1-2-3 is displaying.

(Continued)

Name	Description
LEARN (ALT-F5)	Turns on learn feature and records subsequent keystrokes in learn range. Press LEARN (ALT-F5) again to turn off learn feature.
NAME (F3)	**POINT mode:** Displays a menu of named ranges. **FILES and NAMES modes:** Switches between displaying a menu of names in third line of control panel and displaying a full-screen menu of names. **VALUE mode:** When pressed after typing + − / ^ (or * in a formula, displays a menu of named ranges.
QUERY (F7)	**READY mode:** Repeats last /Data Query you specified. **FIND mode:** Switches 1-2-3 between FIND mode and READY mode.
RUN (ALT-F3)	**READY mode:** Displays a list of range names so you can select the name of the macro you want to run. If you press ESC after pressing RUN (ALT-F3), 1-2-3 switches to POINT mode so you can highlight the first cell of the macro you want to run.
STEP (ALT-F2)	Turns on STEP mode, which executes macros one step at a time for debugging. Press STEP (ALT-F2) again to turn off STEP mode.

Allways Keys

In Allways, you can use many of the same pointer-movement keys and special keys that you are accustomed to using in 1-2-3. The following tables contain descriptions of additional keys you can use in Allways.

Allways Function Keys

Name	Description
DISPLAY (F6)	**ALLWAYS mode:** Switches screen display between graphics mode and text mode.
ENLARGE (ALT-F4)	**ALLWAYS mode:** Enlarges display. Keep pressing ENLARGE (ALT-F4) to enlarge cells up to 140% of their normal size.
GOTO (F5)	**ALLWAYS mode:** Moves cell pointer directly to cell or named range you specify.
GRAPH (F10)	**ALLWAYS mode:** Turns on graph display so you can see actual graphs on the screen. Press again to turn off graph display and display only hatched boxes that indicate range in which a graph is positioned. **NOTE** Your screen display must be in graphics mode in order for you to see the actual graphs when you use GRAPH (F10).

(Continued)

Name	Description
HELP (F1)	Displays an Allways Help screen.
NAME (F3)	**POINT mode:** Displays a menu of named ranges in the worksheet.
	FILES mode: Displays a menu of file names.
REDUCE (F4)	**ALLWAYS mode:** Reduces the display. Keep pressing REDUCE (F4) to reduce cells down to 60% of their normal size.

Allways Accelerator Keys

You must specify the range you want to format before pressing an accelerator key:

- To format a single cell, move the cell pointer to that cell and press the accelerator key.
- To format a range, press . (period) to anchor the cell pointer, highlight the range you want, and then press the accelerator key.

Many of the keys listed in the following table cycle among two or more formats — keep pressing the accelerator key until the choice you want appears.

Name	Description
ALT-B	Boldface: Set/Clear
ALT-G	Print grid: On/Off
ALT-L	Lines: Outline/All/None
ALT-S	Shading: Light/Dark/Solid/None
ALT-U	Underline: Single/Double/None
ALT-1	Sets Font 1
ALT-2	Sets Font 2
ALT-3	Sets Font 3
ALT-4	Sets Font 4
ALT-5	Sets Font 5
ALT-6	Sets Font 6
ALT-7	Sets Font 7
ALT-8	Sets Font 8

File Names

Each operating system has its own guidelines for naming files, which are described in detail in your operating system documentation. In general, however, file names can be any combination of uppercase and lowercase letters, numbers, _ (underscores), and - (hyphens). They should not include spaces or

contain more than eight characters. File names can also have extensions that consist of a . (period) followed by three characters.

1-2-3 automatically adds an extension appropriate to the type of file you are naming as shown in the following table:

File type	Extension
Backup worksheet file	.BAK
Graph file	.PIC
Print or text file	.PRN
Worksheet file	.WK1

Allways automatically adds an extension appropriate to the type of file you are naming as shown in the following table:

File type	Extension
Allways format file	.ALL
Encoded print file	.ENC
Font set library file	.AFS
Layout library file	.ALS

Macro Library Manager automatically adds the extension .MLB to macro library files when you name them.

Label Prefixes

The following table lists 1-2-3 label prefixes:

Prefix	Result
'	Aligns label with left edge of cell.
"	Aligns label with right edge of cell.
^	Centers label in cell.
\	Repeats characters in label to fill cell.

NOTE The ¦ (split vertical bar) is also a label prefix. It is used primarily for embedded setup strings (see Appendix B of *Reference*) and /Data Parse format lines (see Chapter 4 of *Reference*). If used as a label prefix for a label that is located at the beginning of a row of data, the ¦ tells 1-2-3 not to print the row. If, however, the label is located elsewhere in a row (such as between other labels), the label will be left-aligned and will not print.

Operators and Precedence Numbers

The following table shows the arithmetic, string, and logical operators you can use in formulas and their order of precedence. The lower the precedence number, the earlier 1-2-3 performs the operation. Operations with the same precedence number are performed sequentially from left to right.

Operator	Operation	Precedence number
^	Exponentiation	1
– or +	Identification of value as negative or positive	2
* or /	Multiplication or division	3
+ or -	Addition or subtraction	4
= or <>	Equal-to or not-equal-to tests	5
< or >	Less-than or greater-than tests	5
<=	Less-than-or-equal-to test	5
>=	Greater-than-or-equal-to test	5
#NOT#	Logical-NOT test	6
#AND# or #OR#	Logical-AND or logical-OR tests	7
&	String concatenation	7

1-2-3 @Functions

This section lists the 1-2-3 @functions in alphabetical order. Arguments for each @function are in italics. You must provide the required arguments.

@@(*location*) returns contents of the cell *location* refers to.

@ABS(*x*) calculates absolute (positive) value of *x*.

@ACOS(*x*) calculates arc cosine of *x*.

@ASIN(*x*) calculates arc sine of *x*.

@ATAN(*x*) calculates arc tangent of *x*.

@ATAN2(*x,y*) calculates four-quadrant arc tangent of *y/x*.

@AVG(*list*) averages values in *list*.

@CELL(*attribute,range*) returns information about an *attribute* for the first cell in *range*.

@CELLPOINTER(*attribute*) returns information about an *attribute* for current cell.

@CHAR(*x*) returns the character that corresponds to LICS code *x*.

@CHOOSE(*offset,list*) returns value or string in *list* specified by *offset*.

@CLEAN(*string*) removes control characters from *string*.

@CODE(*string*) returns LICS code for first character in *string*.

@COLS(*range*) counts columns in *range*.

@COS(*x*) calculates cosine of angle *x*.

@COUNT(*list*) counts nonblank cells in a *list* of ranges.

@CTERM(*interest,future-value,present-value*) calculates number of compounding periods for an investment (*present-value*) to grow to a *future-value*, given a fixed periodic *interest* rate.

@DATE(*year,month,day*) calculates date number for *year*, *month*, and *day*.

@DATEVALUE(*string*) calculates date number for a *string* that looks like a date.

@DAVG(*input,field,criteria*) averages values in a *field* of a database (*input* range) that meet criteria in the *criteria* range.

@DAY(*date-number*) calculates the day of the month, an integer from 1 to 31, in *date-number*.

@DCOUNT(*input,field,criteria*) counts nonblank cells in a *field* of a database (*input* range) that meet criteria in the *criteria* range.

@DDB(*cost,salvage,life,period*) calculates depreciation allowance of an asset using the double-declining balance method.

@DMAX(*input,field,criteria*) finds the largest value in a *field* of a database (*input* range) that meets criteria in the *criteria* range.

@DMIN(*input,field,criteria*) finds the smallest value in a *field* of a database (*input* range) that meets criteria in the *criteria* range.

@DSTD(*input,field,criteria*) calculates population standard deviation of values in a *field* of a database (*input* range) that meet criteria in the *criteria* range.

@DSUM(*input,field,criteria*) adds values in a *field* of a database (*input* range) that meet criteria in the *criteria* range

@DVAR(*input,field,criteria*) calculates population variance of values in a *field* of a database (*input* range) that meet criteria in the *criteria* range.

@ERR returns the value ERR (error).

@EXACT(*string1,string2*) returns 1 (true) if *string1* and *string2* are the same; 0 (false) if not.

@EXP(*x*) calculates value of *e* (approximately 2.718282) raised to the power *x*.

BEST AVAILABLE COPY

@**FALSE** returns the logical value 0 (false).

@**FIND**(***search-string,string,start-number***) calculates first occurrence of *search-string* in *string*, beginning with *start-number*.

@**FV**(***payments,interest,term***) calculates future value of a series of equal *payments*, given a periodic *interest* rate and number of payment periods (*term*).

@**HLOOKUP**(***x,range,row-offset***) returns contents of cell in specified row (*row-offset*) of horizontal lookup table (*range*).

@**HOUR**(***time-number***) calculates the hour, an integer from 0 to 23, in *time-number*.

@**IF**(***condition,x,y***) evaluates *condition* and returns *x* if *condition* is true; *y* if false.

@**INDEX**(***range,column-offset,row-offset***) returns value in cell located at specified *column-offset* and *row-offset* in *range*.

@**INT**(*x*) returns integer portion of *x*, without rounding the value.

@**IRR**(***guess,range***) calculates internal rate of return for a series of cash flows in *range*, based on the percentage *guess*.

@**ISAAF**(***name***) returns 1 (true) if *name* is a defined add-in @function; 0 (false) if not.

@**ISAPP**(***name***) returns 1 (true) if *name* is an attached add-in @function; 0 (false) if not.

@**ISERR**(*x*) returns 1 (true) if *x* is the value ERR; 0 (false) if not.

@**ISNA**(*x*) returns 1 (true) if *x* is the value NA; 0 (false) if not.

@**ISNUMBER**(*x*) returns 1 (true) if *x* is a value or a blank cell; 0 (false) if *x* is a string.

@**ISSTRING**(*x*) returns 1 (true) if *x* is a string; 0 (false) if *x* is a value or a blank cell.

@**LEFT**(***string,n***) returns first *n* characters in *string*.

@**LENGTH**(***string***) counts characters in *string*.

@**LN**(*x*) calculates natural logarithm (base *e*) of *x*.

@**LOG**(*x*) calculates common logarithm (base 10) of *x*.

@**LOWER**(***string***) converts all letters in *string* to lowercase.

@**MAX**(***list***) finds largest value in *list*.

@**MID**(***string,start-number,n***) returns *n* characters from *string*, beginning with character at *start-number*.

@**MIN**(***list***) finds smallest value in *list*.

@MINUTE(*time-number*) calculates the minutes, an integer from 0 to 59, in *time-number*.

@MOD(*x,y*) calculates remainder (modulus) of *x/y*.

@MONTH(*date-number*) calculates the month, an integer from 1 to 12, in *date-number*.

@N(*range*) returns the entry in first cell of *range* as a value.

@NA returns the value NA (not available).

@NOW calculates date and time numbers that correspond to the current date and time based on your computer's clock.

@NPV(*interest,range*) calculates net present value of a series of future cash flows (*range*), discounted at a fixed, periodic *interest* rate.

@PI returns the value π (calculated at 3.1415926536).

@PMT(*principal,interest,term*) calculates amount of periodic payment needed to pay off a loan (*principal*), given a specified *interest* rate and number of payment periods (*term*).

@PROPER(*string*) converts letters in *string* to proper capitalization: the first letter of each word uppercase with remaining letters lowercase.

@PV(*payments,interest,term*) calculates present value of a series of equal *payments*, discounted at a periodic *interest* rate and given a number of payment periods (*term*).

@RAND generates random number between 0 and 1.

@RATE(*future-value,present-value,term*) calculates periodic interest rate necessary for investment (*present-value*) to grow to a *future-value*, given a number of compounding periods (*term*).

@REPEAT(*string,n*) duplicates *string* *n* times.

@REPLACE(*original-string,start-number,n,new-string*) replaces *n* characters in *original-string* beginning at *start-number*, with *new-string*.

@RIGHT(*string,n*) returns last *n* characters in *string*.

@ROUND(*x,n*) rounds value *x* to *n* places.

@ROWS(*range*) counts rows in *range*.

@S(*range*) returns the entry in first cell of *range* as a label.

@SECOND(*time-number*) calculates the seconds, an integer from 0 to 59, in *time-number*.

@SIN(*x*) calculates sine of angle *x*.

@SLN(*cost,salvage,life*) calculates straight-line depreciation allowance of an asset for one period.

@SQRT(*x*) calculates positive square root of *x*.

@STD(*list*) calculates population standard deviation of values in *list*.

@STRING(*x,n*) converts value *x* into label with *n* decimal places.

@SUM(*list*) adds values in *list*.

@SYD(*cost,salvage,life,period*) calculates sum-of-the-years'-digits depreciation allowance of an asset for a specified *period*.

@TAN(*x*) calculates tangent of angle *x*.

@TERM(*payments,interest,future-value*) calculates the number of payment periods in the term of an investment necessary to accumulate a *future-value*, assuming *payments* of equal value, when the investment earns a periodic *interest* rate.

@TIME(*hour,minutes,seconds*) calculates time number for *hour*, *minutes*, and *seconds*.

@TIMEVALUE(*string*) calculates time number for a *string* that looks like a time.

@TRIM(*string*) returns *string* with no leading, trailing, or consecutive spaces.

@TRUE returns the logical value 1 (true).

@UPPER(*string*) converts all letters in *string* to uppercase.

@VALUE(*string*) converts number entered as *string* to its actual numeric value.

@VAR(*list*) calculates population variance of values in *list*.

@VLOOKUP(*x,range,column-offset*) returns contents of cell in specified column (*column-offset*) of vertical lookup table (*range*).

@YEAR(*date-number*) calculates the year, an integer from 0 (1900) to 199 (2099), in *date-number*.

Macro Keystroke Instructions

1-2-3 key	Macro keystroke instruction
↓	{DOWN} or {D}
↑	{UP} or {U}
←	{LEFT} or {L}
→	{RIGHT} or {R}
ABS (F4)	{ABS}
APP1 (ALT-F7)	{APP1}
APP2 (ALT-F8)	{APP2}

(Continued)

1-2-3 key	Macro keystroke instruction
APP3 (ALT-F9)	{APP3}
APP4 (ALT-F10)	{APP4}
BACKSPACE	{BACKSPACE} or {BS}
BIG LEFT (CTRL-←) or BACKTAB (SHIFT-TAB)	{BIGLEFT}
BIG RIGHT (CTRL-→) or TAB	{BIGRIGHT}
CALC (F9)	{CALC}
DEL	{DELETE} or {DEL}
EDIT (F2)	{EDIT}
END	{END}
ENTER	~
ESC	{ESCAPE} or {ESC}
GOTO (F5)	{GOTO}
GRAPH (F10)	{GRAPH}
HELP (F1)	{HELP}
HOME	{HOME}
INS	{INSERT} or {INS}
NAME (F3)	{NAME}
PGUP	{PGUP}
PGDN	{PGDN}
QUERY (F7)	{QUERY}
TABLE (F8)	{TABLE}
WINDOW (F6)	{WINDOW}
/ (slash) or < (less-than symbol)	/, <, or {MENU}
~ (tilde)	{~}
{ (open brace)	{{}
} (close brace)	{}}

Advanced Macro Command Summary

This section lists the 1-2-3 advanced macro commands in alphabetical order. Arguments in [ ] (brackets) are optional. When an argument is italicized, you must substitute something else when you enter the command. When an argument is not italicized, you must include the exact word.

{***subroutine*** **[*arg1*],[*arg2*],...,[*argn*]**} performs a subroutine call.

{?} suspends macro execution, letting you type any number of keystrokes.

{**BEEP** **[*tone-number*]**} sounds computer's bell or tone.

{**BLANK** *location*} erases contents of *location*.

{**BORDERSOFF**} turns off display of the worksheet borders.

{**BORDERSON**} redisplays worksheet borders.

{**BRANCH** *location*} transfers macro control from current macro cell to *location* for further macro instructions.

{**BREAK**} returns 1-2-3 to READY mode.

{**BREAKOFF**} disables CTRL-BREAK.

{**BREAKON**} restores use of CTRL-BREAK.

{**CLOSE**} closes the open text file.

{**CONTENTS** ***target-location,source-location,[width],[cell-format]***} copies as a label the contents of *source-location* to *target-location*.

{**DEFINE** ***location1,location2,...,locationn***} stores arguments passed in a subroutine in a {*subroutine*} command so those arguments can be used later in the subroutine.

{**DISPATCH** *location*} performs an indirect branch by transferring macro control to the cell whose name or address is in *location*.

{**FILESIZE** *location*} determines number of bytes in the open text file and enters number in *location*.

{**FOR** ***counter,start-number,stop-number,step-number,subroutine***} creates a for loop — it repeatedly performs a subroutine call to *subroutine*.

{**FORBREAK**} ends a for loop.

{**FRAMEOFF**} turns off display of the worksheet borders. Same as {BORDERSOFF}.

{**FRAMEON**} redisplays the worksheet borders. Same as {BORDERSON}.

{**GET** *location*} suspends macro execution until you press a key, then records keystroke as left-aligned label in *location*.

{**GETLABEL** ***prompt,location***} displays *prompt* in control panel, waits for your response, and stores whatever you typed as a left-aligned label in *location*.

{**GETNUMBER** ***prompt,location***} displays *prompt* in control panel, waits for your response, and stores whatever you typed as a number in *location*.

{**GETPOS** *location*} enters as a number in *location* the current byte pointer position in the open text file.

{**GRAPHOFF**} removes a graph displayed by {GRAPHON}.

{**GRAPHON** ***[named-graph],[nodisplay]***} displays the current graph or a named graph.

{IF *condition*} evaluates *condition*. If *condition* is true, macro moves to instruction immediately following {IF} command in the same cell; if false, moves to next cell.

{INDICATE [*string*]} changes mode indicator to *string*.

{LET *location,entry*} enters number or left-aligned label (*entry*) in *location*.

{LOOK *location*} checks the keyboard buffer for keystrokes and enters as left-aligned label in *location* the first keystroke (if any).

{MENUBRANCH *location*} displays in control panel the macro menu found at *location*, waits for you to select an item, then branches to the associated macro instructions.

{MENUCALL *location*} displays in control panel the macro menu found at *location*, waits for you to select an item, then performs a subroutine call to the associated macro instructions.

{ONERROR *branch-location,[message-location]*} continues macro execution at *branch-location* if an error occurs.

{OPEN *file-name,access-type*} opens a specified text file for read-only or read-and-write processing.

{PANELOFF [clear]} freezes control panel and status line, optionally clearing contents.

{PANELON} unfreezes control panel and status line.

{PUT *location,column-offset,row-offset,entry*} enters number or left-aligned label (*entry*) in specified column and row in a range (*location*).

{QUIT} immediately ends the macro and returns 1-2-3 to READY mode.

{READ *byte-count,location*} starts at byte pointer position in the open text file, copies *byte-count* number of bytes to *location*, and advances byte pointer *byte-count* bytes.

{READLN *location*} starts at byte pointer position in the open text file, copies remainder of current line to *location*, and moves byte pointer to beginning of next line.

{RECALC *location,[condition],[iterations]*} recalculates values in *location*, proceeding row by row.

{RECALCCOL *location,[condition],[iterations]*} recalculates values in *location*, proceeding column by column.

{RESTART} clears subroutine stack during subroutine execution.

{RETURN} affects flow of control in subroutines by returning macro control to the next instruction after {*subroutine*} or {MENUCALL}, or by ending the current iteration in a for loop and starting the next iteration.

{SETPOS *offset-number*} positions byte pointer in the open text file *offset-number* bytes from the first byte.

{SYSTEM *command*} temporarily suspends the 1-2-3 session and executes the specified operating system command.

{WAIT *time-number*} suspends macro execution and displays WAIT as the mode indicator until the time specified by *time-number*.

{WINDOWSOFF} freezes worksheet area of screen during macro execution and suppresses settings sheet display.

{WINDOWSON} restores normal updating of worksheet area and turns on settings sheet display during macro execution. To turn on settings sheet display if a {WINDOWSOFF} command is in effect, use {WINDOWSON} twice: once to redisplay the worksheet area and the second time to redisplay settings sheets.

{WRITE *string*} copies *string* to the open text file, starting at current byte pointer position.

{WRITELN *string*} copies *string*, carriage return, and line feed to the open text file, starting at current byte pointer position.

Task Reference

The "Task Reference" describes 1-2-3, Allways, PrintGraph, and Macro Library Manager tasks and lists the commands you use to complete them. It is organized by category with the task listed on the left and the command you use to accomplish the task, or a reference to a specific part of the Release 2.2 documentation, on the right. Use the "Task Reference" to help you identify a specific command for completing a task and then refer to the description of the command in *Reference* for specific procedures.

Controlling Worksheet Appearance in 1-2-3

Changing Text Display

Change the label alignment (left, right, or center) in a range *after* you enter labels	/Range Label
Convert text in a long label into a row of individual entries	/Data Parse
Enter numbers as labels	Type a label prefix before the number
Rearrange a column of labels to fit in a specified range	/Range Justify

Set the label alignment (left, right, or center) for the worksheet *before* you enter labels	/Worksheet Global Label-Prefix

Controlling Columns and Rows

Change the width of all columns	/Worksheet Global Column-Width
Change the width of one column or a range of columns	/Worksheet Column Set-Width or /Worksheet Column Column-Range
Freeze rows and/or columns on the screen so they remain in view when you scroll through the worksheet	/Worksheet Titles
Insert blank columns and rows	/Worksheet Insert
Remove columns and rows	/Worksheet Delete

Displaying Numbers and Formulas in Different Formats

Control how 1-2-3 displays data in the entire worksheet or in a range	/Worksheet Global Format or /Range Format
Display actual formulas, not the results	/Worksheet Global Format Text /Range Format Text
Display blank cells or a label instead of zeros	/Worksheet Global Zero
Reset a range to the global cell format	/Range Format Reset
Set formats for international currency, date, and time	/Worksheet Global Default Other International
Widen a column to display values instead of * (asterisks)	/Worksheet Column Set-Width

NOTE Worksheet Global Format commands and Range Format commands provide the same formatting options. /Worksheet Global Format affects the entire worksheet, while /Range Format affects the area (range) you choose and overrides /Worksheet Global Format.

Using Windows

Display different parts of a worksheet by splitting the screen into two windows	/Worksheet Window
Synchronize window scrolling	/Worksheet Window Sync
Unsynchronize window scrolling	/Worksheet Window Unsync

Controlling Worksheet Appearance in Allways

Applying Formats to a Range

Add boldface to a range	/Format Bold
Add light, dark, or solid shading to a range	/Format Shade
Change thickness of lines created with /Format Lines	/Layout Options Line-Weight
Create horizontal or vertical lines, enclose cells in a box, or outline ranges	/Format Lines
Double-underline a range	/Format Underline Double
Select a color for data in a range	/Format Color
Underline data in a range	/Format Underline Single

Changing Text Display

Rearrange text to fit in a specified range	/Special Justify

Changing Your Screen Display

Change the background, foreground, and cell pointer colors on a color monitor	/Display Colors
Display graphs on the screen or represent them as hatched boxes	/Display Graphs
Reduce or enlarge the worksheet on the screen	/Display Zoom
Switch between graphics and text modes	/Display Mode

Controlling Columns and Rows

Change the height of a row or range of rows	/Worksheet Row
Change the width of one column or a range of columns	/Worksheet Column

Copying and Moving Formats

Apply the format of another worksheet to the current worksheet	/Special Import
Copy the format of one range to another range	/Special Copy
Move the format of one range to another range	/Special Move

Using Fonts

Change the default font (the worksheet font, except for individually changed cells)	/Format Font 1 Replace
Change the font specified for a range	/Format Font Use
Create a new default font set (for use with all new worksheets)	/Format Font Default Save
Define a font set based on fonts supplied by Allways and that your printer supports	/Format Font Replace for each font you wish to change
Replace current font set with the default font set	/Format Font Default Restore
Retrieve a font set to use with the current worksheet	/Format Font Library Retrieve
Save the font set for future use	/Format Font Library Save

Converting Formulas into Numbers or Labels

Convert a range of formulas to numbers or labels	/Range Value
Convert the formula in the current cell into a number or label	Press EDIT (F2), then press CALC (F9), and then press ENTER
Copy a range, switching rows and columns and converting all formulas to numbers or labels	/Range Trans
Copy data from a range to a worksheet file on disk, converting formulas to numbers or labels	/File Xtract

Copying Data

Convert a range of formulas to numbers	/Range Value
Copy a range, switching rows and columns and converting all formulas to numbers	/Range Trans
Copy a value from a file on disk into the current worksheet	See "Linking Files" in Chapter 1 of *Reference*
Copy data from a range to a worksheet file on disk	/File Xtract
Copy data from one part of the worksheet to another	/Copy
Copy labels and values from a worksheet file on disk to the current worksheet	/File Combine Copy

Data Analysis

Create a frequency distribution of values in a range	/Data Distribution
Invert a matrix formed by rows and columns of data	/Data Matrix Invert
Multiply two matrices	/Data Matrix Multiply
Perform a what-if analysis or cross-tabulate information and enter the results in a table	/Data Table 1 or 2
Perform linear regression analysis	/Data Regression

Databases

Add a field to a database	/Worksheet Insert Column
Add a record to a database	/Worksheet Insert Row
Create a 1-2-3 database	See "1-2-3 Databases" in Chapter 4 of *Reference*
Delete records from a database	/Data Query Delete

Extract records from a database to another area of the worksheet	/Data Query Extract
Extract records from a database, eliminating duplicates	/Data Query Unique
Find and edit records in a database	/Data Query Find
Perform calculations using data from selected records in a database	See "Using Data Table 1 [2] with a Database" in Chapter 4 of *Reference*
Sort records in a database	/Data Sort

Editing Data

Editing Data in 1-2-3

Convert text in a long label into a row of individual entries	/Data Parse
Edit the contents of a cell	Press EDIT (F2) (see "Editing an Entry" in Chapter 1 of *Reference)*
Erase the contents of a cell	/Range Erase
Find or replace text in formulas and/or labels	/Range Search

Editing Data in Macro Library Manager

Copy the contents of a macro library in memory to the worksheet to make changes to the library	Edit

Entering Labels, Numbers, and Formulas

Enter a character that is not on the keyboard	See "Entering LICS Characters" in Appendix A
Enter labels and numbers	See "Entering and Editing Data" in Chapter 1 of *Reference*
Enter numbers as labels	Type a label prefix before the number and press ENTER
Recalculate linking formulas in the current worksheet that refer to files on disk	/File Admin Link-Refresh

Record 1-2-3 keystrokes automatically in a specified range	/Worksheet Learn (see "Using the Learn Feature to Create Macros" in Chapter 14 of *Reference*)
Write formulas	See "Working with Formulas" in Chapter 1 of *Reference*
Write formulas that create a link between two files	See "Linking Files" in Chapter 1 of *Reference*

Erasing Data

Erase data in one or more cells	/Range Erase
Clear the current worksheet from memory and start over with a blank worksheet	/Worksheet Erase Yes
Remove one or more columns or rows	/Worksheet Delete
Remove the current worksheet and replace it with a worksheet file on disk	/File Retrieve

Fixing Mistakes

Edit data entered in a cell	Press EDIT (F2) (see "Editing an Entry" in Chapter 1 of *Reference*)
Erase data in one or more cells	/Range Erase
List error messages, causes, and possible solutions	Press HELP (F1) and select "Error Message Index" from the Help Index
Locate a circular reference in a file	/Worksheet Status or /Worksheet Global
Undo the most recent action in a worksheet	Press UNDO (ALT-F4) when the undo feature is on (see "Using the Undo Feature" in Chapter 1 of *Reference*)

Graphing Data

Creating Graphs

Assign all graph data ranges at once when data is located in consecutive columns or rows	/Graph Group
Clear some or all of the current graph settings	/Graph Reset
Display a named graph	/Graph Name Use
Display and print graphs in color	/Graph Options Color
Display graphs in black and white	/Graph Options B&W
Display the current graph	/Graph View or press **GRAPH (F10)**
Indicate individual ranges of data that you want to graph.	/Graph X, A, B, C, D, E, F
Save a graph in a file to print with Allways or PrintGraph	/Graph Save
Save a named graph with its settings so you can view it again when you use the worksheet	/Graph Name Create then /File Save
Select the kind of graph you want to display	/Graph Type

Adding Text to Graphs

Add graph titles and axis titles	/Graph Options Titles
Add text below a graph to label the data ranges represented by each symbol, color, or hatch pattern	/Graph Options Legend
Control the number of labels displayed on the x-axis	/Graph Options Scale Skip
Label the points or bars in a graph	/Graph Options Data-Labels
Label the slices in a pie chart	/Graph X

Enhancing Graph Format

Add horizontal or vertical grid lines	/Graph Options Grid
Change the format of the numbers displayed along each axis	/Graph Options Scale (Y-Scale, X-Scale) Format

Explode one or more slices in a pie chart	/Graph B with 100 added to the color or hatch pattern number of the slice(s) you want to explode
Set the appearance of lines in line and XY graphs	/Graph Options Format
Set the axis scaling	/Graph Options Scale
Set the hatch pattern or color of each slice in a pie chart	/Graph B with the range containing the numbers 1 to 8 to differentiate color or hatch pattern

Including Graphs in a Worksheet with Allways

Change fonts in a graph	/Graph Settings Fonts
Change margins around a graph	/Graph Settings Margins
Change scaling of fonts in a graph	/Graph Settings Scale
Delete a graph from the worksheet	/Graph Remove
Display graphs in the worksheet	/Display Graphs Yes
Include a graph in the worksheet	/Graph Add
Indicate which directory contains the PrintGraph fonts	/Graph Settings Fonts-Directory
Move or resize a graph	/Graph Settings Range
Set the colors of data ranges in a graph	/Graph Settings Colors
Specify the resolution for printed graphs	/Print Configuration Resolution

Listing Information

List file names, sizes, dates, and times last modified, in a table	/File Admin Table
List global default settings	/Worksheet Global Default /Worksheet Global Default Status
List information about memory use, hardware, and worksheet settings	/Worksheet Status /Worksheet Global
List named graphs in a table	/Graph Name Table

222

List range names and their addresses in a table	/Range Name Table
List the current graph settings	/Graph
List the current print settings	/Print [Printer or File]
List the names of files with a specified extension in the current directory or files that are linked by formulas	/File List

Moving Data

Move data to another part of the worksheet	/Move

Printing

Printing Data in 1-2-3

Change the default print settings for a worksheet	/Print [Printer or File] Options
Control margins, borders, page length, headers, footers, and setup strings. These settings override the /Worksheet Global Default Printer settings.	/Print [Printer or File] Options
Control the default print settings	/Worksheet Global Default Printer
Indicate the range of data you want to print	/Print [Printer or File] Range
List the default print settings that 1-2-3 automatically uses when you start 1-2-3	/Worksheet Global Default Status
Print a header or footer on each page	/Print [Printer or File] Options Header or Footer
Print a range without margins	/Print [Printer or File] Options Margins None
Print a range without page breaks, headers, footers, or top and bottom margins	/Print [Printer or File] Options Other Unformatted

Print contents of all cells in the print range as you see them or as cell entries — formulas and formats	/Print [Printer or File] Options Other As-Displayed or Cell-Formulas
Print nonadjacent columns next to each other	/Worksheet Column Hide
Print worksheet row and/or column borders	/Print [Printer or File] Options Borders
Print worksheets on a printer selected with /Worksheet Global Default Printer Name	/Print Printer
Reset some or all of the current print settings to the default print settings	/Print [Printer or File] Clear
Save data in a text file in ASCII format for use with programs that can read text files	/Print File
Put a marker in the worksheet to tell 1-2-3 where to start printing on a new page	/Worksheet Page
Select the line spacing and pitch of printed text	/Print [Printer or File] Options Setup

Printing Data and Graphs in Allways

Change fonts in a graph	/Graph Settings Fonts
Change scaling of fonts in a graph	/Graph Settings Scale
Change the printing orientation (landscape or portrait)	/Print Configuration Orientation
Include or suppress the worksheet grid in the printout	/Layout Options Grid
Indicate page on which to end printing	/Print Settings End
Indicate page on which to start printing	/Print Settings Begin
Indicate the number of copies to print	/Print Settings Copies
Indicate the page number for the first page to be printed	/Print Settings First

Indicate the range of data you want to print	/Print Range Set
Print a header or footer on each page	/Layout Titles
Print repeating borders	/Layout Borders
Print worksheets and graphs on a printer you selected with /Print Configuration Printer	/Print Go
Put a marker in the worksheet to tell Allways where to start printing on a new page	/Worksheet Page
Reset the current print settings to the default print settings	/Print Settings Reset
Save data in an encoded print file that you can print at a later time with an operating system command	/Print File
Set the colors of data ranges in a graph	/Graph Settings Colors
Set the paper dimensions	/Layout Page-Size
Specify hardware options (printer, interface, font cartridge, and so on)	/Print Configuration
Specify print options for page numbering and number of copies to be printed	/Print Settings
Specify the resolution for printed graphs	/Print Configuration Resolution

Printing Graphs in PrintGraph

Control whether PrintGraph advances the paper after printing a graph or whether it pauses before printing a graph	Settings Action
Indicate which directory contains the graph files to print	Settings Hardware Graphs-Directory
Preview selected picture file	Select Image-Select, highlight a graph file, and then press **GRAPH (F10)**

Print selected graphs on a printer you selected with Settings Hardware Printer	Go
Replace the current settings with those in the PrintGraph configuration file (.CNF)	Settings Reset
Save the current settings in the PrintGraph configuration file	Settings Save
Select a graph to print	Image-Select
Select the color and hatch patterns for the data in a graph	Settings Image Range-Colors
Select the font for the text in a graph	Settings Image Font
Select the orientation of a printed graph	Settings Image Size Full Settings Image Size Manual Rotation
Select the paper dimensions	Settings Hardware Size-Paper
Select the size and proportion of a printed graph	Settings Image Size Settings Image Size Manual

Setting Up 1-2-3 to Work with a Printer

Select the default connection between your computer and your printer (parallel, serial, or output device)	/Worksheet Global Default Printer Interface
Select the default printer that you want 1-2-3 to use from a list of printers you chose when you used Install	/Worksheet Global Default Printer Name

NOTE Before you can use /Worksheet Global Default Printer Name to select a printer, you must use the Install program to select drivers for the text printers you want to use with 1-2-3.

Setting Up Allways to Work with a Printer

Change the font cartridge	/Print Configuration Cartridge
Change the paper feed option	/Print Configuration Bin
Select the default connection between your computer and your printer (parallel, serial, or output device)	/Print Configuration Interface

Select the default printer that you want Allways to use from a list of printers you chose when you used the Allways Setup program	/Print Configuration Printer

NOTE Before you can use /Print Configuration Printer to select a printer, you must use the Allways Setup program to select drivers for the printers you want to use with Allways.

Setting Up PrintGraph to Work with a Printer

Indicate which directory contains the PrintGraph font files	Settings Hardware Fonts-Directory
Select the default connection between your computer and your printer (parallel, serial, or output device)	Settings Hardware Interface
Select the default printer that you want PrintGraph to use from a list of printers you chose when you used Install	Settings Hardware Printer
Specify the directory that contains the graph files to print	Settings Hardware Graphs-Directory

NOTE Before you can use Settings Hardware Printer to select a printer, you must use the Install program to select drivers for the graphics printers you want to use with PrintGraph.

Protecting Data and Files

Check worksheet protection status	/Worksheet Status
Hide cells in a range	/Range Format Hidden
Hide columns	/Worksheet Column Hide
Hide values equal to zero	/Worksheet Global Zero Yes
Prevent anyone from using a worksheet file	See "Saving a File with a Password" in Chapter 5 of *Reference*
Prevent cells in a range from being changed when /Worksheet Global Protection is on	/Range Protect
Prevent or allow changes to data in a worksheet	/Worksheet Global Protection

Prevent two people from saving changes simultaneously to a shared file	/File Admin Reservation
Restrict cell pointer movement for data entry in unprotected cells	/Range Input
Unprotect specific cells to allow data entry when /Worksheet Global Protection is on	/Range Unprotect

Ranges

Defining and Using Ranges in 1-2-3

Assign a name to a range of cells	/Range Name Create
Delete all range names	/Range Name Reset
Delete one range name	/Range Name Delete
Indicate a range in the worksheet	See "Specifying a Range" in Chapter 1 of *Reference*
Use a label entered in one cell as the range name for an adjacent cell	/Range Name Labels

Using Ranges in Allways

Indicate a range in the worksheet	See "Specifying a Range" in Chapter 18 of *Reference*

Using Ranges in Macro Library Manager

Indicate a range in the worksheet	See "Specifying a Range" in Chapter 1 of *Reference*

Transferring Data Between 1-2-3 and Other Programs

Enter data from a text file into the current worksheet in separate cells	/File Import Numbers with a delimited text file /File Import Text and /Data Parse with a nondelimited text file
Translate files from 1-2-3 Release 2.2 into dBASE II®, dBASE III®, DIF®, or 1-2-3 Release 1A	Use the Translate utility (see Chapter 16 of *Reference*)

Translate files from dBASE II, dBASE III, Multiplan®, and files in DIF format into 1-2-3 Release 2.2 files	Use the Translate utility (see Chapter 16 of *Reference*)
Save data in a text file in ASCII format for use with programs that can read text files	/Print File

Working with Files

Copying Data from Worksheet Files on Disk

Add values from a worksheet file on disk to numbers or blank cells in the current worksheet	/File Combine Add
Copy data from a worksheet file on disk to the current worksheet	/File Combine Copy
Subtract values in a worksheet file on disk from numbers or blank cells in the current worksheet	/File Combine Subtract
Write formulas that refer to cells in worksheet files on disk (link files)	See "Linking Files" in Chapter 1 of *Reference*

Erasing Files in 1-2-3

Clear the current worksheet from memory and start over with a blank worksheet	/Worksheet Erase
Clear the current worksheet from memory and start over with a file from disk	/File Retrieve
Erase a file on disk	/File Erase

Erasing Files in Allways

Erase a font set library file on disk	/Format Font Library Erase
Erase a page layout library file on disk	/Layout Library Erase

Reading Files from Disk in 1-2-3

Change the directory for the current session	/File Directory
Copy all or part of a worksheet file into the current worksheet	/File Combine

Copy a text file into the current worksheet	/File Import
Read a file from disk into memory, replacing the current worksheet	/File Retrieve
Select the directory in which 1-2-3 automatically reads and saves files when you begin a session	/Worksheet Global Default Directory

Reading Files from Disk in Allways

Read a font set library file from disk into memory, replacing the current font set	/Format Font Library Retrieve
Read a page layout library file from disk into memory, replacing the current page layout	/Layout Library Retrieve
Read the default font set into memory	/Format Font Default Restore
Read the default page layout into memory	/Layout Default Restore

Reading Files from Disk in Macro Library Manager

Copy the contents of a library file on disk into memory so you can use the library	Load

Saving Files on Disk in 1-2-3

Backup an existing worksheet file	/File Save Backup /File Xtract Backup
Save a file with a password	/File Save and /File Xtract
Save a range of data, converting formulas to values, in a worksheet file on disk	/File Xtract Values
Save a range of data, including formulas, in a worksheet file on disk	/File Xtract Formulas
Save data in a text file on disk that is in ASCII format	/Print File
Save the current graph settings in a picture file on disk	/Graph Save
Save the current worksheet in a file on disk	/File Save

Saving Files on Disk in Allways

Save print output in an encoded file on disk	/Print File
Save the current font set in a font set library file on disk	/Format Font Library Save
Save the current page layout in a page layout library file on disk	/Layout Library Save
Save the current worksheet format in a file on disk	Use /File Save in 1-2-3. This saves the worksheet data in a .WK1 file and the Allways format information in a .ALL file with the same name.

Saving Files on Disk in Macro Library Manager

Move the contents of a range and its range names into a macro library in memory and to a library file on disk	Save

Using Text Files

Enter data from a text file in the current worksheet in separate cells	/File Import Numbers with a delimited text file /File Import Text and /Data Parse with a nondelimited text file
Save data in a text file in ASCII format	/Print File

Using Add-In Programs

Assign an add-in to a function key so you can run it by pressing that key	/Add-In Attach 7—10 /Worksheet Global Default Other Add-In Set 1—8
Cancel an auto-attach add-in and remove the add-in from memory	/Worksheet Global Default Other Add-In Cancel
Read an add-in into memory	/Add-In Attach
Run an add-in after attaching it	/Add-In Invoke
Run an add-in if you have assigned it to a function key	**ALT-F7, ALT-F8, ALT-F9, ALT-F10**
Specify an add-in for 1-2-3 to read into memory automatically at the beginning of each session	/Worksheet Global Default Other Add-In Set

Remove all add-ins from memory	/Add-in Clear
Remove an add-in from memory	/Add-In Detach

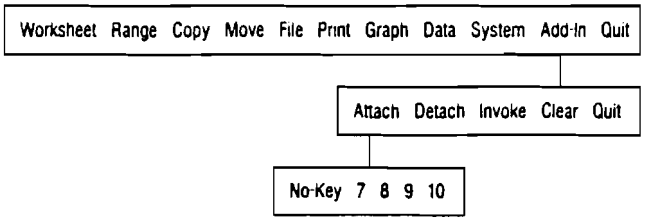
Using Macros

Create a macro library that you can use with any worksheet	Use Macro Library Manager (see Chapter 17 of *Reference*)
Record 1-2-3 keystrokes automatically in a specified range	See "Using the Learn Feature to Create Macros" in Chapter 14 of *Reference*
Run an autoexecute macro when 1-2-3 reads the file into memory	/Worksheet Global Default Autoexec Yes
Use sample macros	See "Sample Macros" in Chapter 14 of *Reference*
Write a macro to perform 1-2-3 tasks	See "Creating a Macro" in Chapter 14 of *Reference*

1-2-3 Menu Trees

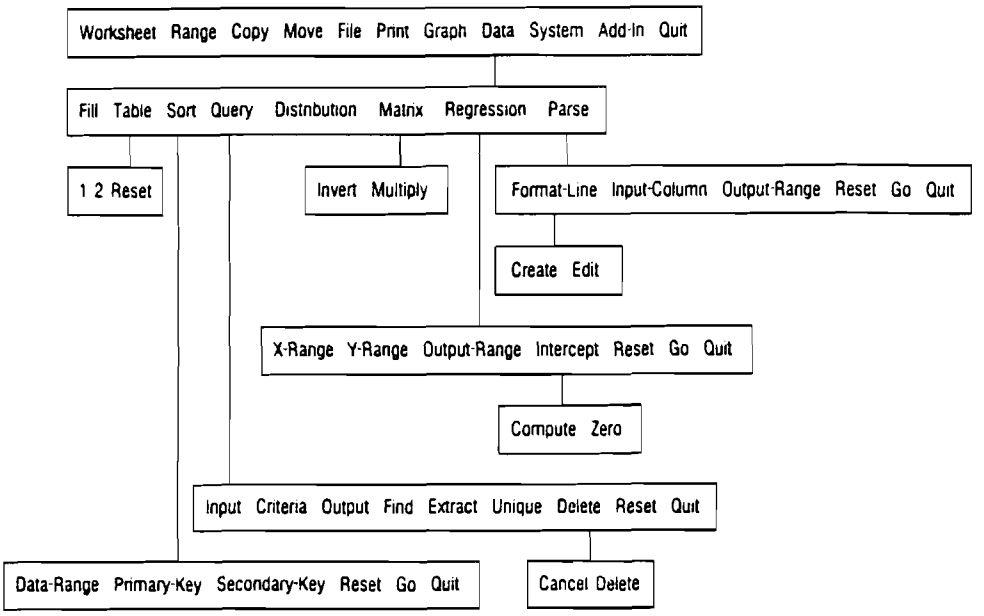
The following pages provide graphic representations of the commands available in the programs that come in your Release 2.2 package: 1-2-3, Allways, Macro Library Manager, and PrintGraph.

The Add-In Commands

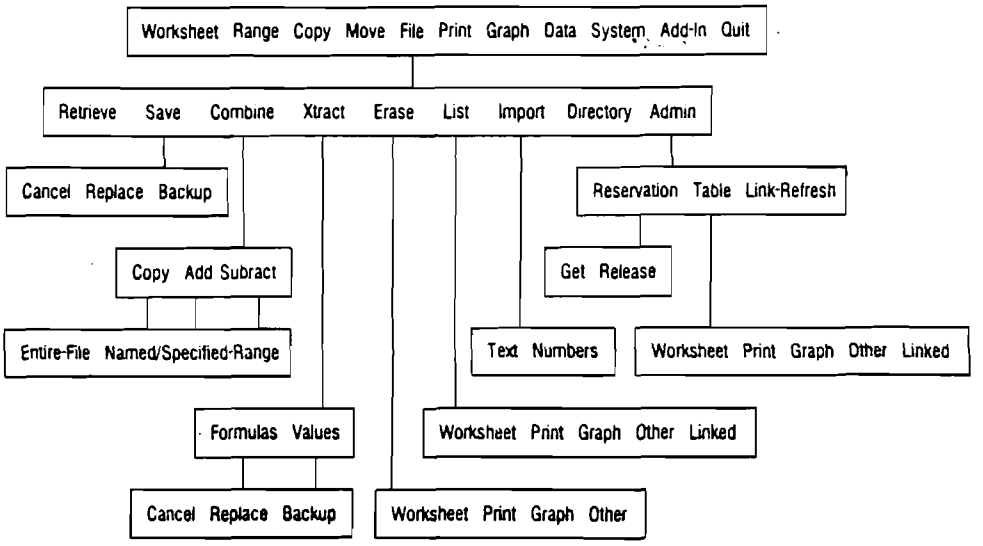


232

The Data Commands

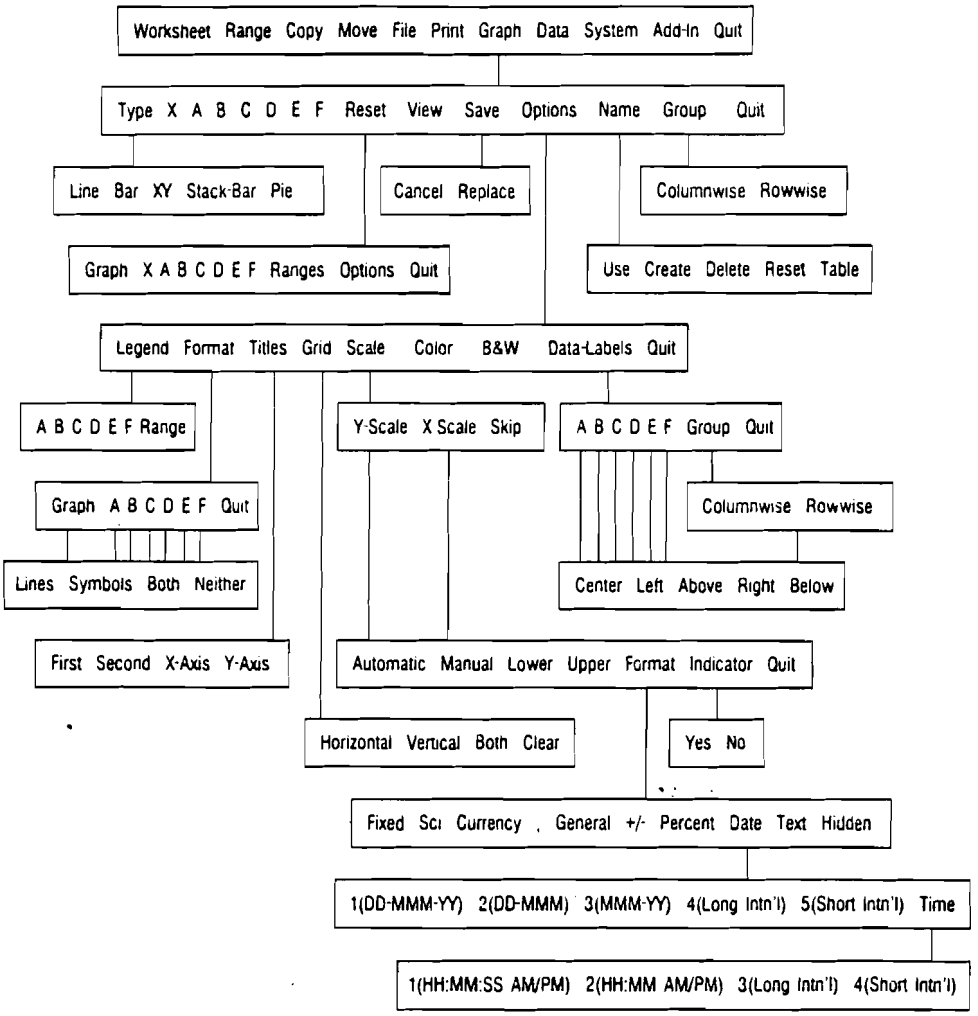


The File Commands

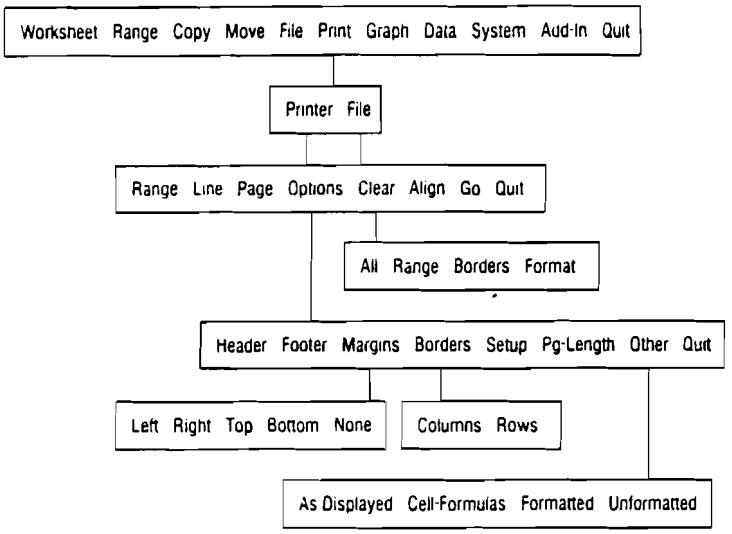


233

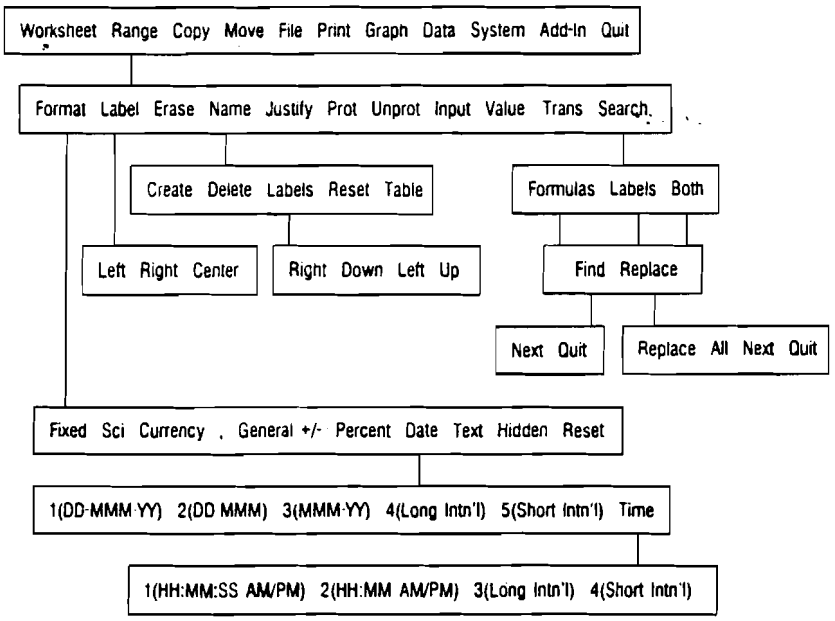
The Graph Commands



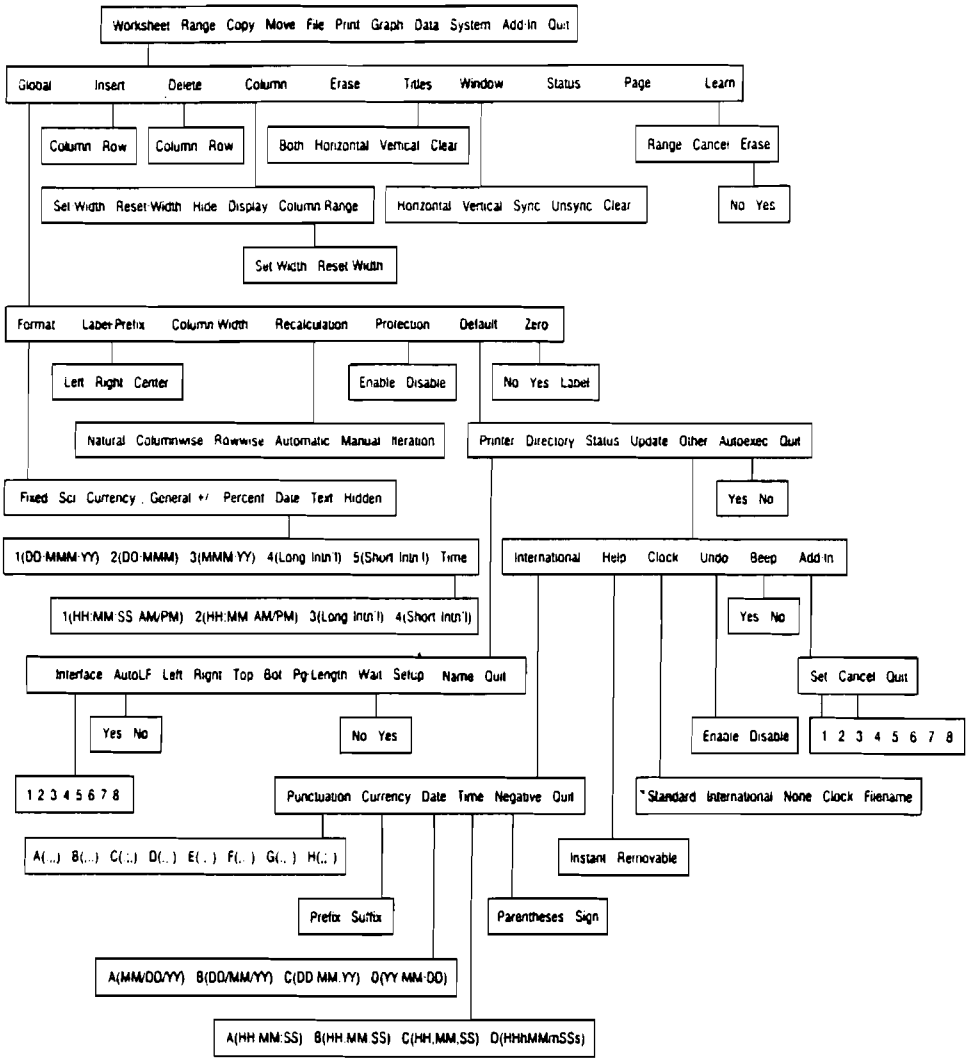
The Print Commands



The Range Commands

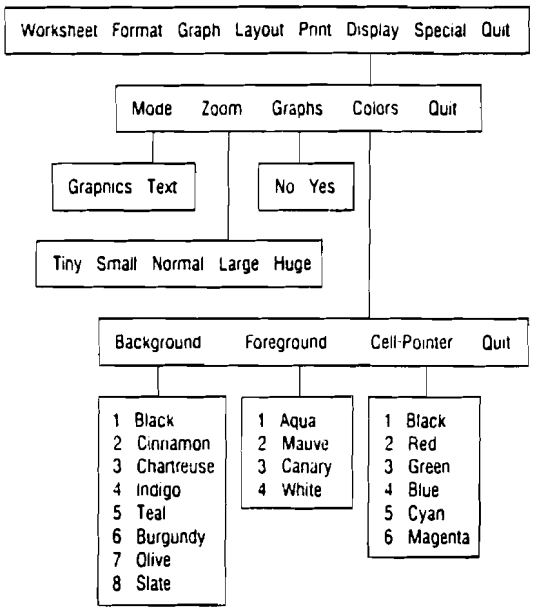


235

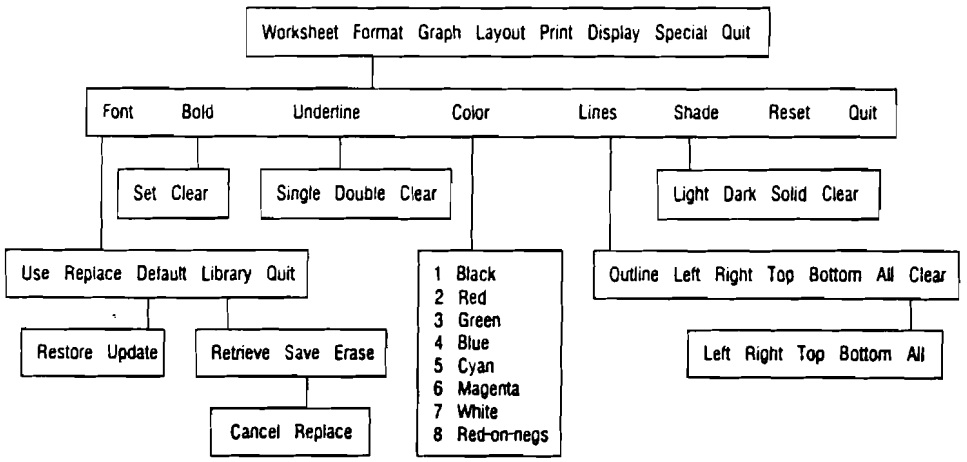

Worksheet Range Copy Move File Print Graph Data System Add-In Quit
Global Insert Delete Column Erase Titles Window Status Page Learn
Column Row
Column Row
Both Horizontal Vertical Clear
Range Cancel Erase
Set Width Reset Width Hide Display Column Range
Horizontal Vertical Sync Unsync Clear
No Yes
Set Width Reset Width
Format Label-Prefix Column Width Recalculation Protection Default Zero
Left Right Center
Enable Disable
No Yes Label
Natural Columnwise Rowwise Automatic Manual Iteration
Printer Directory Status Update Other Autoexec Quit
Fixed Sci Currency , General +/- Percent Date Text Hidden
Yes No
1(DD-MMM-YY) 2(DD-MMM) 3(MMM-YY) 4(Long Intn'l) 5(Short Intn'l) Time
International Help Clock Undo Beep Add-In
1(HH:MM:SS AM/PM) 2(HH:MM AM/PM) 3(Long Intn'l) 4(Short Intn'l)
Yes No
Interface AutoLF Left Right Top Bot Pg-Length Wait Setup Name Quit
Set Cancel Quit
Yes No
No Yes
Enable Disable
1 2 3 4 5 6 7 8
1 2 3 4 5 6 7 8
Punctuation Currency Date Time Negative Quit
Standard International None Clock Filename
A(,.) B(.,) C(:.) D(..) E(.) F(.) G(..) H(:.)
Instant Removable
Prefix Suffix
Parentheses Sign
A(MM/DD/YY) B(DD/MM/YY) C(DD-MM-YY) D(YY-MM-DD)
A(HH:MM:SS) B(HH:MM:SS) C(HH,MM,SS) D(HHhMMmSSs)

Allways Menu Trees

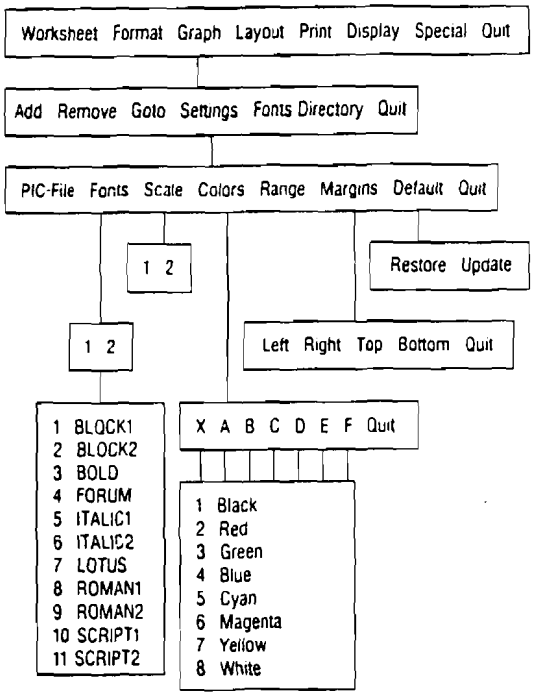
The Display Commands



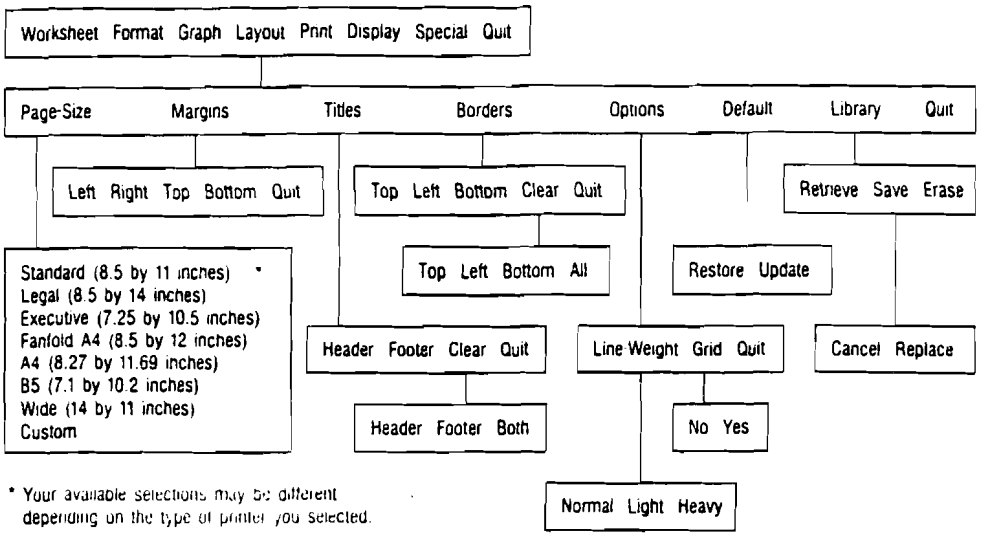
The Format Commands



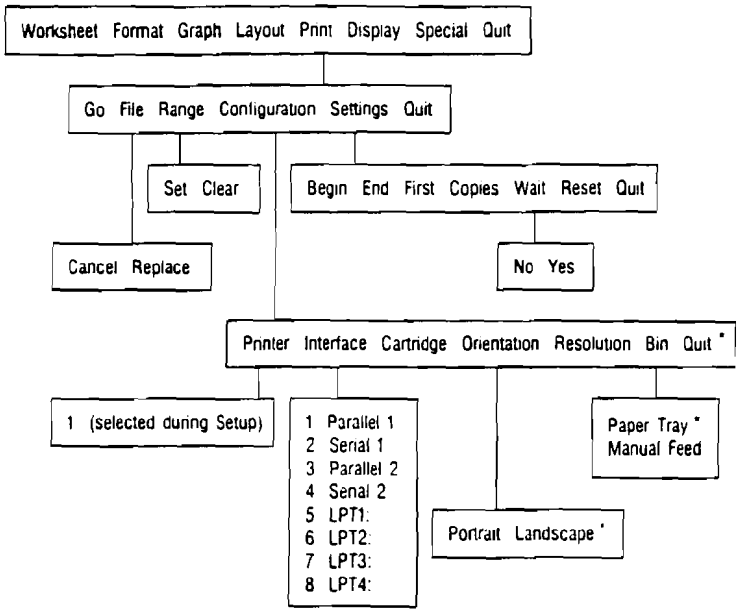
The Graph Commands



The Layout Commands

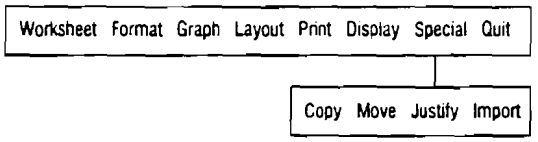


The Print Commands



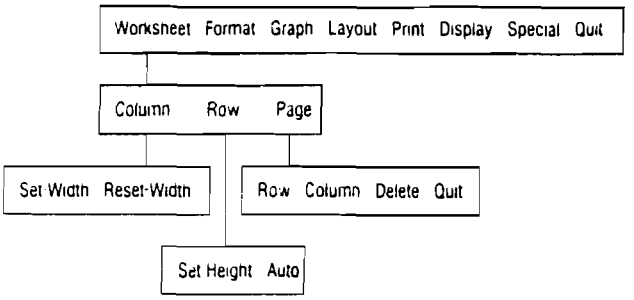
* Your available selections may be different depending on the type of printer you selected.

The Special Commands



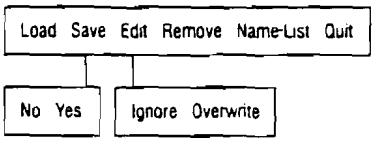
240

The Worksheet Commands

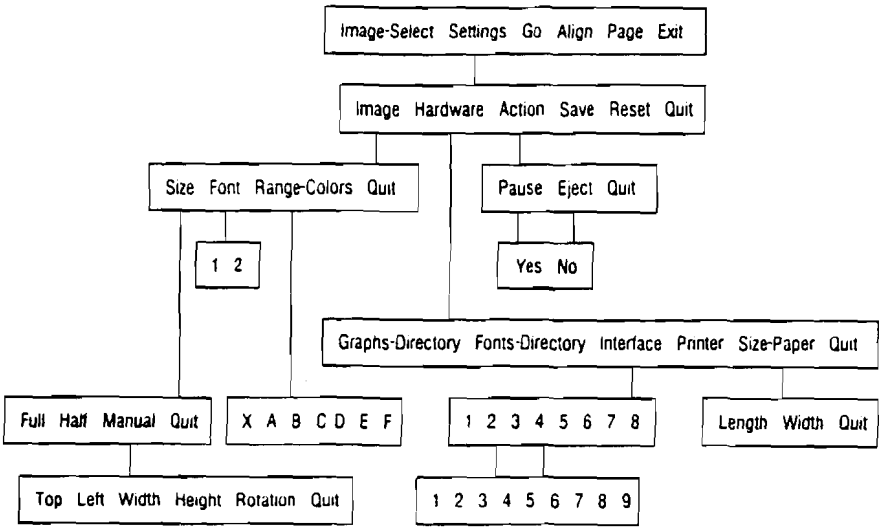


241

Macro Library Manager Menu Tree



PrintGraph Menu Tree



243

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

Under contract to USAID, Bureau of Science and Technology, Office of Agriculture
Project Office: Hampden Square, 4800 Montgomery Lane, Suite 500, Bethesda, MD 20814
Telephone: (301) 913-0500 • Telex: 312636 • Fax: (301) 652-7530 • Fax: (301) 652-7791

AGRICULTURAL AND NATURAL RESOURCES POLICY ANALYSIS COURSE

Optimization in Agricultural Policy Analysis (Using GAMS)

Methods and Guidelines No. 401

Volume 4

Prepared for: Agricultural Policy Analysis Project, Phase II (APAP II)
AID Contract No. DAN-4084-Z-00-8043-00

Author: Carl Gotsch

Prime contractor: **Abt Associates, Inc.**, 55 Wheeler Street, Cambridge, MA 02138 • (617) 492-7100

Subcontractors:

Harvard Institute for International Development, Harvard University, One Eliot Street, Cambridge, MA 02138 • (617) 495-2164
Food Research Institute, Stanford University, Stanford, CA 94305-6084 • (415) 723-3941
North Carolina State University, Department of Economics and Business, Box 7645, Raleigh, NC 27695-7645 • (919) 737-7187
Abel, Daft & Earley, 1410 King Street, Alexandria, VA 22314 • (703) 739-9090
International Science and Technology Institute, 1129 20th Street, NW, Suite 800, Washington, D.C. 20036 •(202) 785-0831
International Food Policy Research Institute, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036 • (202) 862-5600

TABLE OF CONTENTS

PREFACE iii

CHAPTER 1: INTRODUCTION TO LP METHODS 1
MATHEMATICAL STATEMENT OF LP PROBLEM 1
NUMERICAL EXAMPLE: PROGRAMMING IN OUTPUT SPACE 2
COMPARISON WITH BUDGETING (PAM) METHODS 4
NUMERICAL EXAMPLE: PROGRAMMING IN INPUT SPACE 5

CHAPTER 2: GAMS TUTORIAL 7
INTRODUCTION 7
MAYALAND MODEL 8
GAMS PROGRAM REPRESENTATION 8
ANNOTATED GAMS MODEL 9
TUTORIAL TASKS 12
MAYALAND'S DUAL 17

CHAPTER 3: EXPANDING THE MAYALAND MODEL 18
GAMS AS A MATRIX GENERATOR AND REPORT WRITER 18
FACTOR SUBSTITUTION IN L.P. MODELS 24
INCORPORATING DIMINISHING RETURNS 27
SEASONALITY IN FARMING SYSTEMS MODELS 31

CHAPTER 4: DERIVING NORMATIVE DEMAND AND SUPPLY CURVES 38
DERIVING A DEMAND CURVE FOR RESOURCES 38
DERIVING A SUPPLY CURVE FOR OUTPUTS 40

CHAPTER 5: POLICY ANALYSIS: ADDING SOCIAL PRICES 44
COMPUTING AN OPTIMAL SOLUTION AT SOCIAL PRICES 44
COMPARISON OF PRIVATE AND SOCIAL SOLUTIONS 46
COMPUTING CROPWISE PROTECTION COEFFICIENTS 48

CHAPTER 6: FACTOR MARKETS IN THE MAYALAND MODEL 50
ADDING A PRIVATE LABOR MARKET 50
COMPARISON OF MARKET RESULTS (PRIVATE PRICES) 53
ALTERNATIVE ASSUMPTIONS ABOUT LABOR MARKETS 55
ADDING A LABOR MARKET AT SOCIAL PRICES 58
A DETAILED LABOR MARKET MODEL 58

CHAPTER 7: COMPUTING PAMS'S AND DRC'S WITH GAMS 64
CREATING PAMS ON GAMS: SEASONAL LABOR MARKETS 64
CREATING PAMS WITH GAMS: ANNUAL LABOR MARKETS 71

PREFACE

Partial equilibrium budgeting methods continue to be the backbone of much of the analysis on agricultural policy. In their simplest form, budgets provide the evidence that policy makers use to make decisions about private profitability and hence the incentives that farmers have to grow particular commodities. In more sophisticated frameworks, such as the Policy Analysis Matrix (PAM) approach, the same partial methods are extended by using social prices along with private prices in the computations, to examine such issues as comparative advantage and the sources of policy intervention.

The results of programming and budgeting methods are identical if it can be assumed that the competition between crop activities can be reduced to a single resource. When all costs, including the costs of mobile domestic factors such as capital and labor, can be captured in the crop's net revenue calculation, comparative advantage in the use of the unique factor, say, land, is determined by the most profitable enterprise.

It is difficult in many agricultures, however, to characterize the competition for resources in such a straightforward way. In much of the arid and semi-arid tropics, for example, the presence of irrigation makes it possible to grow crops throughout the year, and the ways in which harvesting and planting overlap are important determinants of comparative advantage. Seasonal constraints are made even more complex if water is a scarce resource and its seasonal distribution is determined by precipitation and snow melt.

At a more general level, policy analysts may find it unrealistic to characterize domestic factors such as labor as being completely mobile between the agricultural and non-agricultural sectors. Family labor, for example, often sees working off the farm as fraught with high transaction costs. Analyses about policy response that do not take this and the presence of fixed durable production assets such as animals, tractors and pumps into account tend to overestimate the responsiveness of the sector to policy reforms.

Extending partial equilibrium budgeting methods to take additional fixed factors into account is relatively straightforward. A great deal of data is common to both approaches. Both require, for example, detailed information on production technologies in the form of yields, tradable inputs such as fertilizers, pesticides, seeds, etc. The description of production activities is also standardized in both on a single unit such as an acre, feddan or hectare. In both methods, information on the way in which domestic resources such as land, labor and capital are used and the extent to which markets for these factors exist is crucial to the analysis. However, the difference in assumptions about the extent of fixed factors requires analysts using l.p. methods to develop a more careful inventory of the physical quantities of resources available to the enterprise or the economy.

The following exercises seek to investigate the impact on policy analysis of the assumption that more than one fixed resource is potentially binding on agricultural output. Whether or not this is true is an empirical question and part of the modeling exercise. Additional constraints complicate the determination of comparative advantage, and hence policy recomendations, because of the increased complexity of the trade-offs in the use of resources. Some of this complexity could be reduced if specific binding constraints were known before hand. Optimal resource use could then be

determined by solving a set of simultaneous equations for the levels of various enterprises. However, in the absence of such knowledge, optimization algorithms such as the Simplex method or various "branch and bound" approaches must be employed.

The exercises contained in this manual begin with a simple tutorial developed from data presented in Hazell and Norton's *Mathematical Programming and the Economic Analysis of Agriculture*. This textbook serves not only as source of theory and ideas for the application of l.p. methods, but also as a guide to the sequence of the manual's exercises. For example, as in the book, the first step here is to develop a simple farming systems model based on data drawn from a mythical "Mayaland." This model is expanded to include factor substitution, seasonality, diminishing returns and factor markets. With the addition of demand curves for commodities and supply curves for inputs, the farm level model is used to simulate the behavior of the Mayaland agricultural sector.

The software package used in the course, GAMS, derives its name from its full description as a *G*eneralized *A*lgebraic *M*odeling *S*ystem. It is a computer language designed to facilitate a variety of simulation and optimization modeling activities. Its power is derived from the efficiency with which models that can be specified algebraically can be written down and computed.

The use of GAMS, although powerful and flexible, requires an investment by the user. In this regard, it is perhaps more demanding than other currently available l.p. codes such as Linus Schrage's LINDO or Sunset Software's XA. However, the resulting ability to write readable models and to apply non-linear methods where appropriate more than repays the additional effort required.

Access to GAMS has been made somewhat easier by the publication of Brooke, Kendrick, and Meeraus's *GAMS: A User's Guide* (Scientific Press). This book provides authoritative documentation on the program and should be a part of every analyst's library. Unfortunately, it is not a user friendly "Users Manual." A more readily accessible entry to GAMS is Jefferson and Boisvert, *A Guide to Using the General Algebraic Modelling System (GAMS) for Applications in Agricultural Economics*, Department of Agricultural Economics, Cornell University.

The manual also includes several references to Eric Monke and Scott Pearson, *The Policy Analysis Matrix for Agricultural Development*. In part, these references have been included because l.p. exercises are often best understood by contrasting them with the budgeting methods employed in the book. Perhaps more importantly, however, the book provides an excellent exposition of the general argument that policy interventions can be understood best by comparing private and social prices of outputs, inputs and domestic resources. The two approaches are joined in the manual when GAMS is used to derive individual commodity PAM's based on the optimal solution to an l.p. problem.

The present manual marks the first draft of a number of the GAMS exercises. Although they all have been run in the form presented, typos and discrepancies between the model that ran and the excerpts shown in the text may have occurred. Comments on the exercises are welcomed.

Carl H. Gotsch
July, 1991

CHAPTER 1: INTRODUCTION TO LP METHODS

Chapter 1 provides a brief introduction to l.p. in two dimensions. Although the models are extremely simple, much that prompts an interest in the use of optimization methods in policy analysis becomes apparent in comparing budgeting and programming approaches. (Hazell and Norton provide a similar analysis in their Chapter 2.)

MATHEMATICAL STATEMENT OF LP PROBLEM

When written mathematically, the conventional statement of l.p. models takes the following form:

$$Max \quad Z = \sum_{j=1}^{n} c_j X_j$$

such that

$$\sum_{j=1}^{n} a_{ij} X_j \leq b_i, \qquad all \quad i = 1 \ to \ m$$

and

$$X_j \geq 0, \qquad all \quad j = 1 \ to \ n$$

where

X_j = is the level of the jth farm activity, such as the acreage of corn grown. Let n denote the number of possible activities; then j = 1 to n.

c_j = the forecasted gross margin (gross revenue minus variable costs) of a unit of the jth activity (e.g., dollars per acre).

a_{ij} = the quantity of the ith resource (e.g., acres of land or days of labor) required to produce one unit of the jth activity. Let m denote the number of resources; then i = 1 to m.

b_i = the amount of the ith resource available (e.g., acres of land or days of labor).

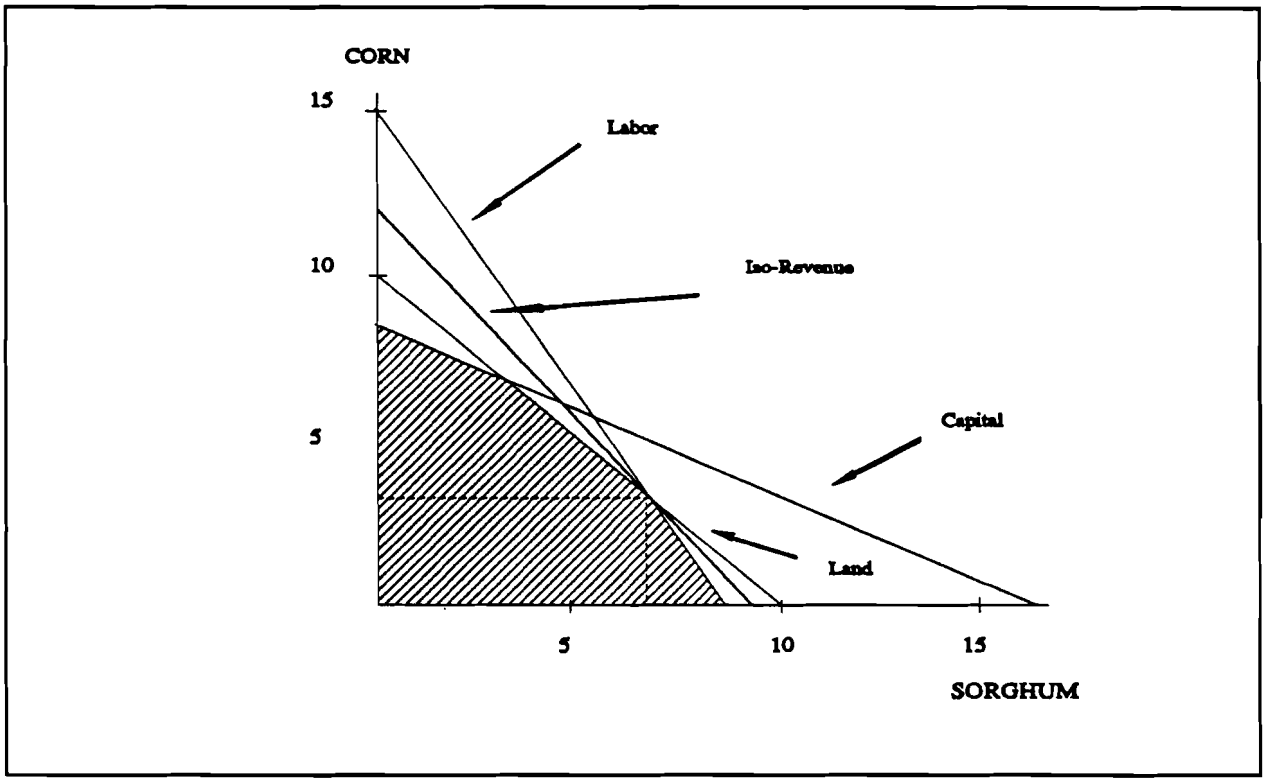
The task is then to find the cropping system (defined by a set of activity levels X_j, j = 1 to n) that has the highest possible total gross margin, Z, but does not violate any of the fixed resource constraints or involve any negative activity levels.

The above problem also is frequently set out in the form of a tableau which makes the data organization more intuitive. The data format is the same as that used in budgeting approaches. Crop and livestock enterprises are shown as columns and the inputs and resources used in their production are described in rows. Production in both methods are assumed to be linear. Any increase in output requires a proportional increase in all inputs and resources. (The generalized tableau is given specific form in a two dimensional graph shown below.)

NUMERICAL EXAMPLE: PROGRAMMING IN OUTPUT SPACE

Constraints/Activities	Corn	Sorghum	RHS
Objective Function ($/acre):	90	120	
Constraints:			
Land (acres)	1	1	<=10
Labor (man days/acre)	6	10	<=90
Capital ($/acre)	10	5	<=80

Figure 1.1: Graphic Solution in Output Space



Algebraic Solution

Alternative 1: All Sorghum

Resource		Technical Coefficients	Max Sorghum Acreage
Land	10	1	10 acres
Labor	90	10	9 acres
Capital	80	5	16 acres

Objective function value of all sorghum = (9 x 120) = 1080

Alternative 2: All Corn

Resource		Technical Coefficients	Max Corn Acreage
Land	10	1	10 acres
Labor	90	6	15 acres
Capital	80	10	8 acres

Objective function value of all corn = (8 x 90) = 720

Alternative 3: Much sorghum, little corn

	Technical Coefficients		Resource
Equation 1 (land)	1 corn + 1 sorghum	=	10
Equation 2 (labor)	6 corn + 10 sorghum	=	90

Solve by substituting 1 corn = (10 - 1 sorghum) in Equation 2.

6 (10 - 1 sorghum) + 10 sorghum = 90
60 - 6 sorghum + 10 sorghum = 90
4 sorghum = 90 - 60
sorghum = 7.5
1 corn + 7.5 = 10
1 corn = 10 - 7.5
corn = 2.5

Objective function: 7.5 sorghum (120) + 2.5 corn (90) = 1125

Alternative 4: Much corn, little sorghum

	Technical Coefficients		Resource
Equation 1 (land)	1 corn + 1 sorghum	=	10

Equation 2 (capital) 10 corn + 5 sorghum = 80

Solve by substituting 1 corn = (10 - 1 sorghum) in Equation 2.

10(10 - 1 sorghum) + 5 sorghum = 80
100 - 10 sorghum + 5 sorghum = 80
-5 sorghum = -2
sorghum = 4
1 corn + 4 = 10
corn = 6

Objective function: 4 sorghum (120) + 6 corn (90) = <u>1020</u>

The algebraic solution confirms the graphic solution, namely, that the optimal cropping pattern would be to grow much sorghum and little corn. Both commodities use equal amounts of the binding land constraint. However, given the ratio of net returns per acre, the bound imposed by the labor constraint is less restrictive than the bound imposed by the capital constraint. Consequently, the corner defined by land and labor yields a higher return than the corner defined by land and capital.

COMPARISON WITH BUDGETING (PAM) METHODS

The graphic solution of a multi-constraint problem in two-dimensional output space provides interesting insights into budgeting methods that assume that cropping enterprises compete for a single resource uniquely fixed to agriculture. Suppose that in the previous output space figure, land was the only binding constraint. In this case, comparative advantage would (1) dictate that all land would be planted to one crop or the other or (2) be indeterminant if the profits from the two enterprises were the same. Budgeting solutions thus represent what in l.p. methods are called "corner solutions". Any adjustments to policy reforms, according to this model, produce all or nothing results. Movements from an optimal solution that recommends much corn and little sorghum to one that recommends little corn and much sorghum, both possible combinations under the assumption that two or more factors are potential constraints, are never outcomes of the model.

The effect of the single constraint assumption can be seen if the fixed capital and labor constraints in the example above are transformed into variable costs. Suppose that the value of a unit of labor is determined by a labor market and is priced at 3. Similarly, assume a unit of capital can be obtained at 2. The net revenue per unit of land of corn then would become 52 (90-6x3-10x2) and the net revenue of sorghum would become 80 (120-10x3-5x2). Under these assumptions, profit would be maximized by growing all sorghum.

Adding more constraints makes the model behave differently when changes are made in relative prices. Indeed, with a large number of constraints, the trade-off between corn and sorghum becomes

NUMERICAL EXAMPLE: PROGRAMMING IN INPUT SPACE

Constraints/Activities	Corn	Sorghum	Beans	RHS
Objective Function:	90	120	50	
Constraints:				
Land	1	1	1	< = 10
Labor	6	10	3	< = 90

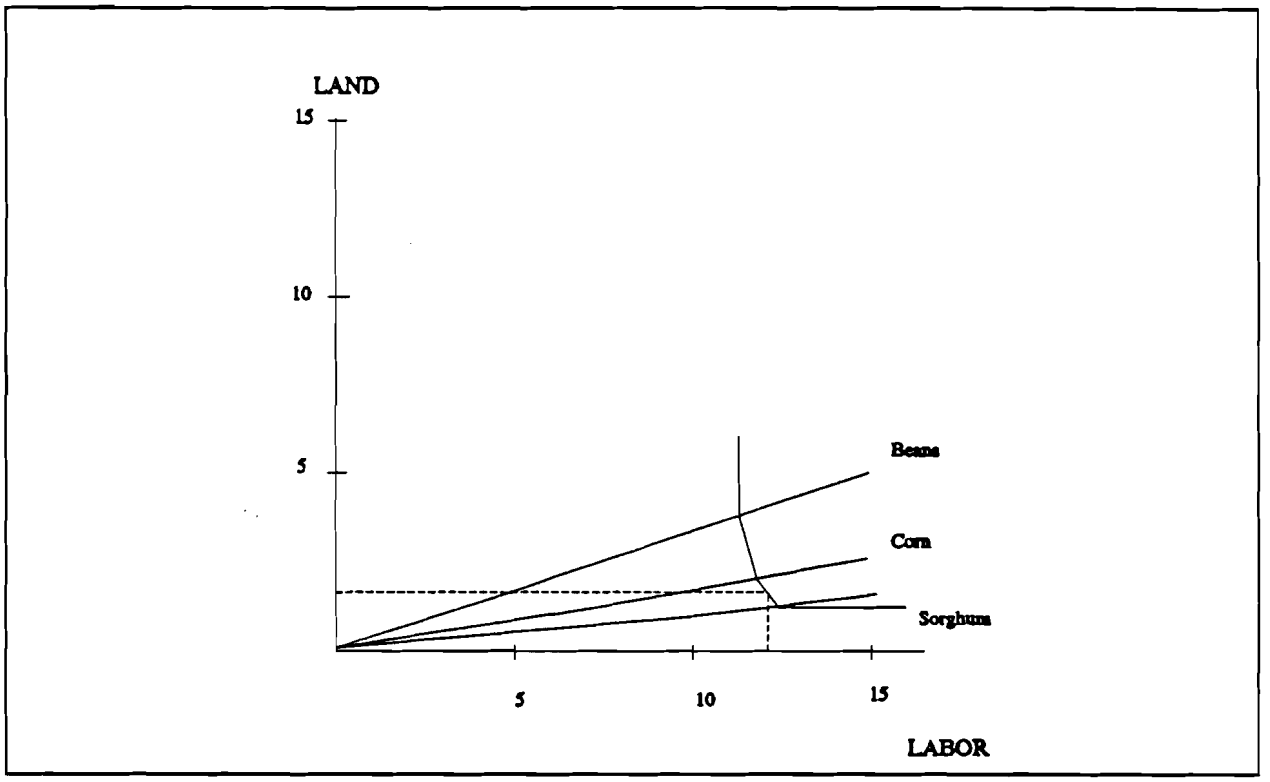


Figure 1.2: Graphic Solution in Input Space

more and more continuous and the adjustment of farmers to changes in relative prices less abrupt. In l.p. methods, this substitution takes place by shifting between technologies and enterprises as the two-dimensional "inputs space" model shown below indicates.

The slopes of the rays emanating from the origin in Figure 1.2 describe the required combination of land and labor needed to produce beans, corn and sorghum. Beans, for example, require one unit of land for every three units of labor. The model can be solved graphically at any point by drawing in the 1:9 ratio of land and labor availability. The resulting intersection of the resource constraint lines with the line linking points of similar revenue on the corn and sorghum rays confirm the result of the previous exercise (Figure 1.1), namely, that with these technical coefficients and relative net revenues, the optimal solution will contain both corn and sorghum.

Figure 1.1 shows how adding constraints decreases the abruptness of the trade-offs between corn and sorghum. Figure 1.2 provides a similar example, namely, increasing the number of technogies can make the trade-off between land and labor less discontinuous. The lesson in both cases is that for l.p. models to behave "realistically," i.e., to avoid simplistic corner solutions, rich technical matrices containing a number technologies and constraints are required.

CHAPTER 2: GAMS TUTORIAL[1]

INTRODUCTION

The easiest way to learn a new computer language or system is by using an example. The exercise used below is taken from the "Mayaland" farm model shown on p. 12, Chapter 2 of the Hazell-Norton text. You will be asked to copy and run it in a GAMS tutorial session described below.

The recommended procedure for using GAMS is to create directories or sub-directories for your data sets and to call GAMS from these directories. For example, suppose there were some sample programs in a sub-directory called GAMSLIB. The first thing you would need to do is to get into the sub-directory called GAMSLIB. (From the DOS prompt: CD\GAMS205\GAMSLIB) GAMS should not be run from the directory containing the GAMS program files, i.e. from C:\GAMS205. Calling can be done from any other directory or, in this case, from a sub-directory under GAMS205.

GAMS programs and data files are written with the help of an external text editor. The Norton Editor (NE.COM) has been included in the GAMS sub-directory, and the exercises assume that it will be used to write the GAMS files. (Any text editor can be used to write GAMS files, e.g., BRIEF, VEDIT, KEDIT, etc. Word processors may also be used, but extreme care must be taken to insure that the DOS text mode is used. GAMS does not recognize non-standard characters--including TAB!--and will crash if these are encountered in the model files.)

The Norton Editor is invoked with the command: NE <Filename>. When started from a directory, NE automatically knows where it is and only the name of the file being retrieved or initiated need be entered. (NE also understands "paths" so it is possible to retrieve files from other directories.) A manual is unnecessary; a complete help file is available (F1) for all cursor and editing commands. The help facility should be consulted from the outset. Learning to use NE's ability to move to the ends of files, define and print blocks, find and replace, etc., will be rewarded amply in reducing the time required to write and examine GAMS programs.

---

[1] GAMS, largely a product of World Bank research efforts, comes on six diskettes that include (1) the GAMS matrix generator/compiler, (2) the BDLP version of the Simplex algorithm for solving linear programming problems, (3) Stanford's MINOS5, a solver for both linear and non-linear problems, (4) HERCULES, a solver for computable general equilibrium (CGE) models, and (5) a diskette, GAMSLIB, containing a number of examples.

Installation of GAMS should be done according to the instructions given in GAMS.DOC. This means basically that GAMS should be installed in a DOS sub-directory called GAMS205, the CONFIG.SYS file parameters should be enlarged, GAMS205 should be included in a path contained in the AUTOEXEC.BAT file, and separate work areas, e.g., sub-directories, should be set up to hold the files containing the actual models.

Hazell and Norton's Mayaland model is set out below, first in the form of a tableau, then in algebraic notation, and finally in an annotated GAMS program. The complete GAMS program to be copied and run is contained in the section entitled "GAMS Model".

MAYALAND MODEL

Tableau

	Corn (ha)	Beans (ha)	Sorghum (ha)	Peanuts (ha)	RHS
Objective Function (pesos)	1372	1219	1523	4874	
Land (ha)	1	1	1	1	<= 5.0
Labor (months)	1.42	1.87	1.92	2.64	<= 16.5
Mules (months)	1.45	1.27	1.16	1.45	<= 10.0
Market Constraint (tons)				.983	<= 0.5

Algebraic Notation

Max: $Z = 1372X_1 + 1219X_2 + 1523X_3 + 4874X_4$

Such that:

$$\begin{aligned} 1.0X_1 + 1.0X_2 + 1.0X_3 + 1.0X_4 &<= 5.0 \\ 1.42X_1 + 1.87X_2 + 1.92X_3 + 2.64X_4 &<= 16.5 \\ 1.45X_1 + 1.27X_2 + 1.16X_3 + 1.45X_4 &<= 10.0 \\ 0.983X_4 &<= 0.5 \end{aligned}$$

$$X_1, \quad X_2, \quad X_3, \quad X_4, \quad >= \quad 0$$

GAMS PROGRAM REPRESENTATION

The basic syntax used to convert the algebraic notation described above into a GAMS program relies on the following definitions:

GAMS Expressions	Interpretation
SETS	A keyword that identifies a group of numbers or a set, e.g., j (crops) or i (resources) in the Mayaland model

PARAMETERS	A keyword that indicates the beginning of the data for a vector or a scalar, e.g., the gross margin of peanuts (crop j) or the availability of land resource i).
TABLE	A keyword to indicate the beginning of a data array e.g., A_{ij} describing the amount of labor (resource i) required to produce sorghum (crop j).
VARIABLES	A keyword to specify a variable, e.g.,the level of crop activity j.
EQUATIONS	A keyword to specify the types of equations included in the model. For example, RESOURCES(I) denotes the constraints on resources available to produce crops.
*	Identifies a line of comments. All the following characters on this line are ignored.

GAMS uses =L=, =E=, =G= to denote the symbols $\leq$, = and $\geq$, respectively.

ANNOTATED GAMS MODEL

Consider first the crops and resources that are shown in the Mayaland model. These are described in GAMS input as follows:

```
SETS
        J  CROPS       / CORN, BEANS, SORGHUM, PEANUTS /
        I  RESOURCES   /LAND, LABOR, MULES, MARKETING/
```

As noted above, the word SETS is a keyword in GAMS that identifies a specific type of input. It can be typed anywhere in the line. The letter J is the name of a set and the word CROPS is the text that describes the set. The letter I is also the name of a set and the word RESOURCES describes the content of the set. The result, as the table -- Table A(I,J) --in the tutorial below indicates, is to emulate the standard mathematical notation for linear programming problems.

The elements of the set are indicated in lines set off by slashes, one at the beginning, one at the end. They are set off from each other by commas. (Elements are also referred to at times as "labels" because they play the role of row and column headings when data are organized in a table format.)

The structure of the SETS statement is common to many GAMS statements. The keyword in this case is SETS. The declaration consists of two parts: the name, which is a single word (an identifier) of ten characters or less; and the text, which may consist of several words. The definition

refers to the list of elements in the set. The element names (labels) can be ten characters long but cannot have embedded blanks.

After having defined the sets over which the computations are to be made, GAMS then requires that the data for the parameters be entered. This is done under the heading of the keyword: PARAMETERS.

Parameters that linear programming models require include the values for the elements in the objective function, the values describing resource availabilities (the "right hand side"), and the technical coefficients matrix. These values are given below for the Mayaland problem.

```
PARAMETERS

C(J)    GROSS MARGINS OF CROP ACTIVITIES (PESOS PER ACRE)
      / CORN 1372, BEANS  1219, SORGHUM  1523, PEANUTS 4874 /

B(I)    RESOURCE AVAILABILITY
      / LAND  5, LABOR  16.5, MULES  10, MARKET  .5 /;
```

A powerful GAMS facility that allows parameters to be calculated in the equations section will be introduced in Chapter 3. It is possible to disaggregate input-output data and to enter only coefficients such as prices, yields, and costs. Gross margins then can be calculated in a subsequent part of the program as Prices x Yields - Costs. This ability to transform raw data into coefficients required by the linear programming problem has caused some people to refer to GAMS as a "matrix generator." In subsequent exercises using parametric programming techniques, it also will become apparent that such disaggregation makes it possible to vary individual parameters such as prices and yields without having to go back to the aggregate gross margin figures. This capability can be expanded to include much of the data processing that ordinarily is done exogenously with other l.p. software packages.

The syntax of the parameter statement again is worth noting. First comes the keyword (PARAMETERS) that tells GAMS what kind of information is to follow. Then comes the name of the parameter. In this case there are two: C (the values of the objective function elements); and B (the values of constraints or the "right hand side "). After that there is a statement about the "domains" to which the parameters refer. In the case of C, the domain entry (J) tells GAMS that the ensuing entries refer to crops. Similarly, (I) tells GAMS that the B parameter refers to resources. The text that follows explains what the parameter refers to and is optional. Finally, the statement contains the "definition" part of the PARAMETERS entry specifying the actual element values.

A great time saver in creating l.p. models is software that can read technical coefficient tables rather than the line-by-line entry required by many l.p. packages. (See Linus Schrage's LINDO or Sunset Software's XA for examples of the latter.) Given the definition of sets above, i.e., J refers to

crops and I refers to resources, the technical coefficient matrix can be specified as a traditional "a_{ij}" matrix.

As in all virtually all computer languages, sub-scripts show up in parentheses. GAMS understands that the word TABLE refers to parameters unless told otherwise and, in this case, that the domains are I and J. The element a(i,j) defines the ith resource used in the production of the jth crop. (In the GAMS matrix notation, rows always come before columns.)

TABLE A(I,J) TECHNICAL COEFFICIENTS MATRIX

	CORN	BEANS	SORGHUM	PEANUTS
LAND	1	1	1	1
LABOR	1.42	1.87	1.92	2.64
MULES	1.45	1.27	1.16	1.45
MARKET				.983
+				
	OTHER CROPS		OTHER CROPS	
LAND				
LABOR				
MULES				
MARKET				

Tables can be extended simply by typing a + on the next line (see above) and continuing. (The GAMS technical manual contains more precise rules and regulations for table expansion.)

GAMS also requires a declaration of the variables in the problem. (The keyword is VARIABLES.) In this case, when written in set notation, there are two--the variable that represents the summation of the objective function and the variable that describes the levels of the different crop activities. In addition, GAMS must be informed at this point which variables must be positive, e.g., all the crop activities. (This latter condition is the familiar stipulation that $X_j \geq 0$)

```
VARIABLES
        Z       TOTAL GROSS MARGINS (DOLLARS)
        CROPS     LEVELS OF CROP ACTIVITIES (HECTARES)

        POSITIVE VARIABLE CROPS;
```

After the variables have been declared, i.e., the activities identified, it is necessary to declare the names of the equations and to spell out the relationships that hold in the model. This is also the point at which statements can be used to calculate parameters, e.g., gross margins can be calculated from yields, prices, and costs. Again, these elements can be written in set notation and do not require the laborious row-by-row entry of LINDO or XA.

```
EQUATIONS

    OBJFN          OBJECTIVE FUNCTION
    CONSTRNT(I)    RESOURCE CONSTRAINTS;


OBJFN..          Z =E= SUM(J, C(J)*CROP(J));
CONSTRNT(I)..     SUM(J, A(I,J)*CROP(J))        =L= B(I);
```

Remaining to be completed are the definition of the model, instructions regarding the appropriate solver to use, and the objective function to be maximized or minimized. ("All" means to use all the equations that have been defined earlier.) Each of the statments must be ended with a semi-colon.

```
MODEL  MAYALAND /ALL/;

SOLVE MAYALAND USING LP MAXIMIZING Z;
```

TUTORIAL TASKS

The complete GAMS model of the Mayaland example is shown below. This exercise should be done from a sub-directory that houses your data. Create the sub-directory using the DOS MD command. Enter it using DOS's Change Directory (CD) command. Once in the sub-directory, type NE to invoke the Norton Editor. When asked for the file name, type: MAYALAND. You should then have a blank screen and you can begin typing in the tutorial indicated below.

GAMS Model

Type the model shown below beginning with the line "$TITLE". Take care in typing in the model; it will save a good deal of time in debugging. Especially pesky is the need to put a semi-colon after many GAMS statements. Those separated by a keyword are not required to have a semi-colon, but GAMS will do strange things if the semi-colon is left out elsewhere. (A frequent trouble spot is at the end of the EQUATION definition command. You must put a semi-colon before going on to write out the equation detail because there is no intervening keyword. Subsequently, each equation must also have a semi-colon at the end.)

```
------------------------------------------------------------------------
$TITLE                              MAYALAND TUTORIAL

    SETS        J       ACTIVITIES          /CORN, BEANS, SORGHUM, PEANUTS/
                I       CONSTRAINTS         /LAND, LABOR, MULES, MARKET/
```

```
PARAMETERS

          C(J)   GROSS MARGINS OF CROP ACTIVITIES (PESOS PER HECTARES)
                 /CORN 1372, BEANS 1219, SORGHUM 1523, PEANUTS 4874/

          B(I)   RESOURCE CONSTRAINTS
                 /LAND 5, LABOR 16.5, MULES 10, MARKET .5/

TABLE A(I,J)     TECHNICAL COEFFICIENTS

                  CORN        BEANS       SORGHUM         PEANUTS
     LAND          1           1           1               1
     LABOR         1.42        1.87        1.92            2.64
     MULES         1.45        1.27        1.16            1.45
     MARKET                                                .983

VARIABLES

                 Z       TOTAL GROSS MARGINS (PESOS)
                 CROPS   LEVELS OF CROP ACTIVITIES (HECTARES)
                 POSITIVE VARIABLES CROPS;

EQUATIONS

OBJFN          OBJECTIVE FUNCTION
CONSTRNT(I)    RESOURCE CONSTRAINTS;

* Note the two dots below that indicate that an equation follows:

OBJFN..            Z =E=  SUM(J, C(J)*CROPS(J));
CONSTRNT(I)..             SUM(J, A(I,J)*CROPS(J)) =L= B(I);

MODEL MAYALAND /ALL/;
SOLVE MAYALAND USING LP MAXIMIZING Z;
```

REMEMBER: GAMS DOES NOT UNDERSTAND NON-ASCII CHARACTERS. THEREFORE BE SURE NOT TO USE THE TAB KEY WHEN WRITING OUT THE MODEL OR CREATING THE TABLES.

When the model is complete, save it. (It will be saved automatically under the name MAYALAND. There are a number of ways to accomplish this in NE but they all begin by pressing Function Key 3 (F3). Save and exit is F3, E. (Use the help key (F1) if you forget what to use. Also, after pressing F3, a menu of commands appears at the bottom of the screen.)

Run the model by typing GAMS <filename> at the sub-directory's DOS prompt (C:\<DATA_SUB>). The statement is GAMS MAYALAND. If everything has been done

correctly, the model will run and output will be written to a file called MAYALAND.LST. If you have used some other file name, the output file produced by GAMS will be called <FILE NAME>.LST. You can look at this file by typing NE <FILE NAME>.LST. To repeat: there are two files involved. One is the model, called MAYALAND. Another, produced by GAMS, is the output file called MAYALAND.LST.

If there are mistakes, the compilation will abort with an error message. In this case, you must also look at the output file to see where the mistakes are. They are identified by a series of ***** in the row number column and by error message codes at roughly the point of the error. These codes are defined at the end of the output file so you will need to look them up in order to find out what they mean. (Use ALT-F in the NE to find the **** string that identifies where the errors are located.). Remember: mistakes are found in the output (.LST) file, but corrections must be made in the input file. The former contains row numbers; the later does not.

GAMS Output

GAMS produces a great deal of output, much of which can be shut off as you get better acquainted with the model you are running. In the initial phase of creating a model, the symbol listing is helpful in debugging. Like many computer languages, GAMS symbols first must be declared and then defined. The symbol listing also indicates where symbols are referenced so that typos and other syntax mistakes are easier to locate.

The equation listing also is helpful because it transforms the set notation that is used in writing out the model into an equation-by-equation listing. If mistakes have been made in setting up the calculations--but internal domain checking has not been violated--the difficulty may show up here. The equation listing is the most important tool for diagnosing problems with GAMS models once syntax errors have been resolved.

The following output will be discussed in greater detail in lecture sessions. Those with prior l.p. experience will note that the primal and dual values of the optimal solution are at the end of the solution report. Methods of using the GAMS report writer to organize data in the form of tables suitable for inclusion in documents are discussed in Chapter 3.

The first output encountered in MAYALAND.LST is a repetition of the model typed in earlier--but adds line numbers. If mistakes were made, a description of the error codes will be found at the end of this listing. If the run has been successful, the SOLVE statement in the output is followed by a series of definitional and technical statements that can be passed over quickly. After that, GAMS writes out the individual rows and columns of the model. Lastly, GAMS presents a solution report that describes the optimal levels of activity use and the resulting shadow prices of the constraint set. The output shown below begins with the equation listing.

```
------------------------------------------------------------------------
GAMS 2.05 PC AT/XT                          89/03/15 14:29:49  PAGE  2
```

```
MAYALAND TUTORIAL
EQUATION LISTING    SOLVE TUTOR USING LP FROM LINE 38
```

In this section, GAMS prints out the details of the equations it has generated from the model definition section above. It is the best place to check whether the model has been written correctly. Once everything checks out properly, this section can be suppressed. (The default is to print out the first three equations and skip the rest. This may also be changed to print more than three.)

```
---- OBJFN       =E=  OBJECTIVE FUNCTION
OBJFN..  Z - 1372*CROPS(CORN) - 1219*CROPS(BEANS) - 1523*CROPS(SORGHUM)
      - 4874*CROPS(PEANUTS) =E= 0 ;

---- CONSTRNT    =L=  RESOURCE CONSTRAINTS
CONSTRNT(LAND)..  CROPS(CORN) + CROPS(BEANS) + CROPS(SORGHUM) + CROPS(PEANUTS)
     =L= 5 ;

CONSTRNT(LABOR)..  1.42*CROPS(CORN) + 1.87*CROPS(BEANS) + 1.92*CROPS(SORGHUM)
    + 2.64*CROPS(PEANUTS) =L= 16.5 ;

CONSTRNT(MULES)..  1.45*CROPS(CORN) + 1.27*CROPS(BEANS) + 1.16*CROPS(SORGHUM)
    + 1.45*CROPS(PEANUTS) =L= 10 ;

COLUMN LISTING      SOLVE TUTOR USING LP FROM LINE 38
```

This section is the equivalent of the equation listing in that it prints out the details of the columns. It is the easiest way to check the technical coefficients that have been entered in the data tables. Like the equation section, the default is three columns although all may be printed out if desired.

```
---- Z           TOTAL GROSS MARGINS (PESOS)
Z
                 (.LO, .L, .UP =  -INF, 0,  +INF)
        1        OBJFN

---- CROPS       LEVELS OF CROP ACTIVITIES (HECTARES)
CROPS(CORN)         (.LO, .L, .UP = 0, 0,  +INF)
    -1372        OBJFN
        1        CONSTRNT(LAND)
        1.42     CONSTRNT(LABOR)
        1.45     CONSTRNT(MULES)

CROPS(BEANS)       (.LO, .L, .UP = 0, 0,  +INF)
    -1219        OBJFN
        1        CONSTRNT(LAND)
        1.87     CONSTRNT(LABOR)
        1.27     CONSTRNT(MULES)
```

```
CROPS(SORGHUM)     (.LO, .L, .UP = 0, 0,  +INF)
    -1523        OBJFN
        1        CONSTRNT(LAND)
     1.92        CONSTRNT(LABOR)
     1.16        CONSTRNT(MULES)

MAYALAND TUTORIAL
SOLUTION REPORT     SOLVE TUTOR USING LP FROM LINE 38
```

This section prints out the primal and dual solutions. The dual is printed first and lists the levels of the fixed factors along with their upper bounds, i.e., their availability. It also lists their "marginals" or shadow prices. When the level of use is equal to the upper bound, it means that the resource has been exhausted and has a positive shadow price or marginal product. The extent to which the resource is surplus can be found by subtracting "level" from "upper".

```
EXIT -- OPTIMAL SOLUTION FOUND.


---- EQU CONSTRNT     RESOURCE CONSTRAINTS
          LOWER      LEVEL      UPPER     MARGINAL
LAND       -INF       5.000      5.000   1523.000
LABOR      -INF       9.966     16.500          .
MULES      -INF       5.948     10.000          .
MARKET     -INF       0.500      0.500   3408.952
```

This section prints out the value of the objective function, Z.

```
--- VAR Z              -INF   9319.476     +INF       .

  Z           TOTAL GROSS MARGINS (PESOS)
```

The final section gives the levels of the model's activities. The associated "marginals' are often referred to in other l.p. codes as "reduced costs." They indicate how much the objective function would decrease if one unit of the crop were forced into the solution. Those crops already in the optimal solution have reduced costs of zero.

```
---- VAR CROPS        LEVELS OF CROP ACTIVITIES (HECTARES)

            LOWER      LEVEL      UPPER     MARGINAL
CORN            .          .       +INF     -151.000
BEANS           .          .       +INF     -304.000
SORGHUM         .      4.491       +INF            .
PEANUTS         .      0.509       +INF            .

 **** REPORT SUMMARY :   0  NONOPT, 0 INFEASIBLE, 0  UNBOUNDED
```

MAYALAND'S DUAL

Test your understanding of GAMS by running the dual of the Mayaland model (Hazell and Norton, p. 16). As you will note from the reading, "if fixed resources are valued at their marginal value product (or shadow prices), opportunity costs, the total rental value assigned to the inputs of the farm must exactly exhaust total output or gross margin." Computing the values of the fixed resources that would lead to this result requires that (a) the levels of resources become the variables, (b) the activities become the constraints, (c) the direction of the inequalities is reversed, and (d) the objective function is minimized.

It is easy to convert the primal of the Mayaland into its dual. Do not type in the model from scratch. Just make a copy of the primal version (At the DOS prompt, type COPY MAYALAND MAYADUAL). Then, after calling the copied file into the Norton Editor, make the following adjustments (Don't worry about the primal headings):

```
VARIABLES

      Z  TOTAL COSTS (PESOS)
      RESOURCES   LEVELS OF RESOURCE USE
         POSITIVE VARIABLES RESOURCES;

EQUATIONS

   OBJFN    OBJECTIVE FUNCTION
   CONSTRNT(J)           GROSS MARGINS;

   OBJFN..  Z =E=  SUM(I, B(I)*RESOURCES(I));
   CONSTRNT(J)..  SUM(I, A(I,J)*RESOURCES(I)) =G= C(J);

MODEL MAYADUAL /ALL/;
SOLVE MAYADUAL USING LP MINIMIZING Z;
```

Compare the levels of the activities in the dual with the values of the constraints in the primal. Unless one of us has made a mistake, they ought to be the same. Refer to the Hazell and Norton explanation of the relationship between the primal and the dual and be prepared to explain why this is so.

CHAPTER 3: EXPANDING THE MAYALAND MODEL

The Mayaland model introduces a number of programming concepts. Chapter 3 expands the MAYALAND model in a number of ways. First, it is assigned a new name, i.e., MYPRIVT, to indicate that it is the original model at private prices. Then there is an exercise to demonstrate the power of GAMS as a matrix generator and report writer. Although it is not obvious because only very small models have been attempted, the output from GAMS can be voluminous. Hence, developing a capacity to organize the output into legible tables should be practiced from the start.

In subsequent sections, the H-N example on factor substitution is incorporated, diminishing returns to weeding included, and, lastly, seasonal resource use is simulated by adding monthly labor and land constraints.

As in all the examples in this manual, it is assumed that each new exercise takes a previous model as a point of departure. Prudence dictates that a copy of the original model should be used as a starting point rather than the original itself. Then, if something drastic happens, you can always revert to the original model to repair the damage. (In this case, at the DOS prompt of the sub-directory housing your data, type COPY MAYALAND MYPRIVT1.)

As noted earlier, the strategy of the chapter is to work through some of the examples for expanding the basic model discussed in Chapter 3 of Hazell and Norton. Each of the examples indicates how a richer and more varied set of activities and constraints might be developed. As the earlier two dimensional exercises made clear, if the number of trade-offs among crops and technologies is very limited, comparative advantage can be ascertained with straightforward budgeting methods. Because of the need to save time and keep the original models simple, many of the models presented here have budget-like "corner" solutions. But this is a function of the exercises and not a requirement of the methodology.

GAMS AS A MATRIX GENERATOR AND REPORT WRITER

Two aspects of GAMS are explored in the following exercise. The first is its ability to do the often sophisticated arithmetic needed to move from the raw data of statistical reports and field surveys to the data forms required by the programming model. The example in which values for the objective function are calculated endogenously is relatively simple. However, more complex calculations that compute the variance of a distribution or produce piece-wise linearization of non-linear curves will be introduced in subsequent chapters. (In GAMS jargon, these are called "assignment statements.") The versatility of the report generator also will be apparent in later chapters when it is used to compute summary statistics such as nominal protection, effective protection, and domestic resource cost coefficients.

Computing Elements of the Objective Function (MYPRIVT1)

```
$TITLE          MYPRIVT1: BASIC MAYALAND MODEL AT PRIVATE PRICES
$OFFSYMXREF OFFSYMLIST
```

(These two statements turn off cross-referencing and symbol listing in the output listing.)

In the MAYALAND tutorial, the gross margins of the objective function were calculated outside the model. In this version, these values are computed by GAMS before the l.p. solver is called. Most of the computation is straightforward. However, because each crop uses several different types of inputs, an input table must be designed. That, in turn, requires a set that can be used to describe the table's rows.

```
SETS   J      CROPS     /CORN, BEANS, SORGHUM, PEANUTS/
       I      INPUTS    /FERT, PEST, CORNSEED, BEANSEED, SORGSEED, PEASEED/
```

The data below on yields and prices are the numbers that underlay the previous gross margin calculations. These values will be computed in the equations section.

```
PARAMETERS

     YIELDS(J)      YIELDS OF CROP ACTIVITIES (KGS PER HECTARE)
                   /CORN 750, BEANS 375, SORGHUM 775, PEANUTS 983/

     PROUTP(J)      PRICES OF CROP OUTPUT (PESOS PER KG)
                   /CORN  3, BEANS  6, SORGHUM 2.6, PEANUTS 7/

     PRINP(I)       PRICES OF INPUTS (PESOS PER KG)
                   /FERT 14, PEST  300, CORNSEED 5, BEANSEED 8,
                    SORGSEED 5, PEASEED 9/

     LAND(J)       LAND USE (HECTARES)
                   /CORN 1,  BEANS 1,  SORGHUM 1,  PEANUTS 1/

     LABOR(J)      LABOR USE (MAN MONTHS PER HECTARE)
                   /CORN 1.42, BEANS  1.87, SORGHUM  1.92, PEANUTS 2.64/

     MULES(J)       MULE USE (PESOS PER HECTARE)
                   /CORN 1.45, BEANS 1.27, SORGHUM  1.16, PEANUTS 1.45/

     MP(J)         PEANUT YIELD FOR MARKET CONSTRAINT ON PEANUTS (KGS PER HA)
                   /PEANUTS 983/
```

The table below indicates how data may be entered in the form of an array. Arrays are always an efficient way of organizing information and can be

exploited in the GAMS format. Note that rows always come before columns in writing down GAMS indices.

```
TABLE IN(I, J) INPUT USE (KGS PER HECTARE)

                    CORN        BEANS       SORGHUM       PEANUTS
FERT                 50          40           30            70
PEST                .25         .25                        .6
CORNSEED             20
BEANSEED                         50
SORGSEED                                      15
PEASEED                                                     95

SCALARS

     AMTLAND          AMOUNT OF LAND AVAILABLE (HECTARES)          /5/

     AMTLAB           AMOUNT OF LABOR AVAILABLE (MONTHS)           /16.5/

     AMTMULE          MULE POWER AVAILABLE (MONTHS)                /10/
  MARKET      MARKET CONSTRAINT ON PEANUTS(KGS)                   /500/
```

The quantity of resources available was previously entered with a parameter statement. When the structure of the model becomes more complex, it is convenient to be able to isolate individual resources and they are now entered as scalars.

```
VARIABLES
            REVENUE    GROSS REVENUE FROM CROP ACTIVITIES
            COST       INPUT COSTS
            CROPS      LEVELS OF THE CROP ACTIVITIES
            Z          TOTAL VALUE ADDED FROM CROP ACTIVITIES
                      POSITIVE VARIABLES CROPS

EQUATIONS

      REV           COMPUTATION OF GROSS REVENUES
      INCOST        COMPUTATION OF TRADABLE INPUT COSTS
      CONSTL        LAND CONSTRAINT
      CONSTLA       LABOR CONSTRAINT
      CONSTMUL      MULE CONSTRAINT
      MARKT         MARKET CONSTRAINT ON PEANUTS
      OBJFN         OBJECTIVE FUNCTION;
```

The calculations that produce gross margins for the objective function are performed in the following two equations. The calculations could have been performed in the objective function itself. However, some intermediate

```
computations are sometimes advisable because they appear to be less
complicated and therefore are easier to debug.

      REV..      REVENUE -E= SUM(J, YIELDS(J)*PROUTP(J)*CROPS(J));
      INCOST..   COST    -E= SUM((I, J), IN(I, J)*PRINP(I)*CROPS(J));

   The following equations describe the constraints on the farm's fixed
factors: land, labor and mules. The market limit on peanuts is also a "fixed
asset."

      CONSTL..                  SUM(J, LAND(J)*CROPS(J)) -L= AMTLAND;
      CONSTLA..                 SUM(J, LABOR(J)*CROPS(J)) -L= AMTLAB;
      CONSTMUL..                SUM(J, MULES(J)*CROPS(J)) -L= AMTMULE;
      MARKT..                   SUM(J, MP(J)* CROPS(J)) -L= MARKET;
      OBJFN..                   Z -E= REVENUE-COST;

MODEL MYPRIVT1 /ALL/;
SOLVE MYPRIVT1 USING LP MAXIMIZING Z;
-------------------------------------------------------------------------
```

Compare the solution of MYPRIVT1 with the solution in to MAYALAND in Chapter 2. The slight differences results from setting the peanut marketing constraint at 500 Kgs. per hectare instead of the 491 kgs that one-half hectare constraint would imply.

Writing a Report Generator

It takes only a few sessions with GAMS to discover that scrolling through large amounts of output in search of a relatively few numbers is frustrating. Fortunately, several steps can be taken to reduce the amount of output.

Step 1: Turn off the Symbol Reference command and the Symbol List command. (This has already been done. They are the two so-called "dollar" commands that appear immediately after the title statement).

Step 2: Turn off the row and column equation listings and the printout of the solution. These invaluable debugging aids are no longer necessary once the model is running properly. They require the following OPTION statement that may appear anywhere, but is usually put at the head of the model file below the title statment in order to make it easily accessible. These statements should only be used when you have complete confidence that the model is working properly.

```
OPTION LIMROW=0, LIMCOL=0, SOLPRINT=OFF
```

Step 3: The most important thing that can be done to gain control over GAMS output is to begin right from the start to produce report generators as a part of the model's specification. From the l.p. point of view, four elements of the solution are interesting. Each is accessed from the output by appending an "attribute" to the element requested. The four attributes that can be requested are:

.L = the level of an activity or resource in the optimal solution.

.M = the "marginal" of an activity or resource. For resources, the latter, the value is often referred to as the "shadow price." It is also a measure of the resource's marginal value product and reflects the decrease in the objective function if one unit of the resource were withdrawn.

For activities, the "marginal" refers to what in some l.p. codes are called "reduced costs." They describe the reduction in the value of the objective function that would occur if one unit of the activity were forced into the solution.

.LO = Lower bound of the activity or resource.

.UP = Upper bound of the activity or resource. For resources, the difference between the .UP of a resource and the .L of a resource is the slack or excess resource that has not been used.

In addition, other values of interest may be computed in the report generator. For example, in the following exercises, values have been calculated for gross revenues, input costs, and gross margins. These values will become the building blocks for later exercises that compute the impact of commodity specific policies.

The entire process of writing a report generator resembles writing a GAMS model. As in a GAMS model, once a satisfactory module has been written, it can be used repeatedly in other models and other situations. The report generator shown below should be appended immediately following the SOLVE statement in MYPRIVT1. (Ignore the explanatory text when typing in the statements that generate the report.)

```
$TITLE                    REPORT ON MYPRIVT1 SOLUTION

   In producing the summary tables of a GAMS report generator, the elements in
the sets can be thought of as identifying the rows and columns of the desired
tables whereas the parameters identify the names of the tables. NOTE THAT THE
DEFINITIONS USED FOR PARAMETER VALUES MUST NOT HAVE BEEN USED PREVIOUSLY IN
DEFINING THE MODEL.

     SETS      AREP      /GROSSREV, INPUTCO, NETREV, LEVEL/
               CREP      /LAND, LABOR, MULES/
               OBJ       /OBJECTIVE/

     PARAMETERS     ACTREP    VARIABLES SUMMARY
                    CONREP    DOMESTIC RESOURCE USE SUMMARY
                    CONMARG   SHADOW PRICES OF DOMESTIC RESOURCES
                    OBJFUN    OBJECTIVE FUNCTION VALUE;
```

The first three equations of the table ACTREP (activity report) provide a report on the model's activities in the form of calculated revenues, input costs, and gross margins. The fourth equation reports the levels of the activities in the optimal solution using the .L "attribute" command (see previous page). An activity not in the optimal solution will be left blank.

```
ACTREP("GROSSREV", J)   =   YIELDS(J)*PROUTP(J);
ACTREP("INPUTCO", J)    =   SUM(I, IN(I, J)*PRINP(I));
ACTREP("NETREV", J)     =   ACTREP ("GROSSREV", J)- ACTREP("INPUTCO", J);
ACTREP("LEVEL",J)       =   CROPS.L(J);
```

The table reporting the value of the objective function contains only one element. But because it contains a different dimension, i.e., it is not reported by crop, it requires a special statement.

```
OBJFUN("OBJECTIVE")       =     Z.L;
```

The CONREP (constraint report) table reports the amounts used of each fixed resource.

```
CONREP("LAND")            =     SUM(J, CROPS.L(J)*LAND(J));
CONREP("LABOR")           =     SUM(J, CROPS.L(J)*LABOR(J));
CONREP("MULES")           =     SUM(J, CROPS.L(J)*MULES(J));
```

The CONMARG (constraint marginals) table reports the shadow prices of each of the fixed resources.

```
CONMARG("LAND")         =     CONSTL.M;
CONMARG("LABOR")        =     CONSTLA.M;
CONMARG("MULES")        =     CONSTMUL.M;
```

The display statements organize the output of the various parameter values. The results are at the end of the output file. Use NE's End-of-File cursor command (Control-End) to move rapidly to the last line in the output file; then back up until the desired output is found.

```
DISPLAY OBJFUN, ACTREP, CONREP, CONMARG;
```

The report produced by the report generator for MYPRIVT1 is shown below. The output includes one additional line that produces the "reduced cost" for each activity. The reduced cost is given in the original GAMS output report by the "marginal" for activities. Test your understanding of the report generator by adding the line to the report generator that produced the output. Hint: If CROPS.L(J) produced the level of the activity, what attribute would produce the marginal for the set CROPS? If you solve this one, try creating a line in the report generator that reports the surplus resources in the optimal solution rather than the amount used. Hint: Subtract the amount amount used (.L) from the amount available (.UP).

```
REPORT ON MYPRIVT1 SOLUTION
E X E C U T I N G

----     106 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE
OBJECTIVE 9301.933

----     106 PARAMETER ACTREP        VARIABLES SUMMARY

                CORN       BEANS     SORGHUM     PEANUTS
GROSSREV    2250.000    2250.000    2015.000    6881.000
INPUTCO      875.000    1035.000     495.000    2015.000
NETREV      1375.000    1215.000    1520.000    4866.000
LEVEL                                  4.491       0.509
RCOSTS      -145.000    -305.000

----     106 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY
LAND  5.000,    LABOR 9.966,    MULES 5.948

----     106 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES

LAND 1520.000

**** FILE SUMMARY
INPUT   C:\FR230\MYPRIVT1
OUTPUT  C:\FR230\MYPRIVT1.LST
EXECUTION TIME       =        1.870 SECONDS        VER: 386-EK-008
```

FACTOR SUBSTITUTION IN L.P. MODELS

In his famous text, *Economic Theory and Operations Research*, Baumol discusses the relationship between linear programming and neo-classical analysis in the following way:

> In at least one sense, the programming analysis digs deeper than does neoclassical theory. As has already been stated, the neoclassical theory assumes that the optimal technical production processes have somehow already been determined before the economic theorist gets to work on the problem. This premise is an integral part of the very concept of a production function, for, by definition, that function tells us what is the *largest* possible output which can be obtained for every input combination. That is, it assumes that optimal processes are employed to make those inputs go as far as possible. However, the choice of the optimal technological arrangement is no trivial task. It is, however, one which can be handled by the methods of mathematical programming.

In the example below, Baumol's comment is given concrete form in the case of corn. The example is again taken from H-N, p. 34-35. There are two different ways of producing corn which use different combinations of labor and mule power. The choice of technology therefore will be influenced by relative factor endowments. Should one factor become dear relative to another, the model could be expected to move away from the technology that utilizes the expensive factor in the

direction of the one that uses the less expensive resource. Similarly, the same can be said of different crop enterprises. GAMS, of course, does not know that CORNHAND and CORNMULE both refer to the same crop whereas CORN and BEANS refer to different commodities. Both offer opportunities for factor substitution by moving from one activity to another.

Factor Substitution Model (MYPRIVT2)

Add the factor substitution possibilities to the MYPRIVT1 model developed in the previous section. First make a copy of MYPRIVT1 with the command: COPY MYPRIVT1 MYPRIVT2. Then add the activity CORNMULE to create a technology that substitutes mule labor to be substituted for hand labor.

```
$TITLE            MYPRIVT2: BASIC MAYALAND MODEL AT PRIVATE PRICES
$OFFSYMXREF OFFSYMLIST
OPTION LIMROW=0, LIMCOL=0, SOLPRINT=OFF

SETS   J      CROPS      /CORNHAND, CORNMULE, BEANS, SORGHUM, PEANUTS/
       I      INPUTS     /FERT, PEST, CORNSEED, BEANSEED, SORGSEED, PEASEED/

PARAMETERS

  YIELDS(J)  YIELDS OF CROP ACTIVITIES (KGS PER HECTARE)
         /CORNHAND 750, CORNMULE 750, BEANS 375, SORGHUM 775, PEANUTS 983/

  PROUTP(J)  PRICES OF CROP OUTPUT (PESOS PER KG)
        /CORNHAND 3, CORNMULE 3, BEANS  6, SORGHUM 2.6, PEANUTS 7/

  PRINP(I)   PRICES OF INPUTS (PESOS PER KG)
        /FERT 14, PEST  300, CORNSEED 5, BEANSEED 8, SORGSEED 5, PEASEED 9/

  LAND(J)    LAND USE (HECTARES)
        /CORNHAND 1, CORNMULE 1, BEANS 1,  SORGHUM 1,  PEANUTS 1/

  LABOR(J)   LABOR USE (MAN MONTHS PER HECTARE)
        /CORNHAND 2.5, CORNMULE 1.42, BEANS 1.87, SORGHUM 1.92, PEANUTS 2.64/


  MULES(J)   MULE USE (PESOS PER HECTARE)
        /CORNHAND 1, CORNMULE 1.45, BEANS 1.27, SORGHUM  1.16, PEANUTS 1.45/


  MP(J)      PEANUT YIELD FOR MARKET CONSTRAINT ON PEANUTS (KGS/HA)
             /PEANUTS 983/
```

```
TABLE IN(I, J) INPUT USE (KGS PER HECTARE)

             CORNHAND      CORNMULE         BEANS       SORGHUM       PEANUTS
  FERT             50            50            40            30            70
  PEST            .25           .25           .25                         .6
  CORNSEED         20            20
  BEANSEED                                     50
  SORGSEED                                                   15
  PEASEED                                                                  95

            -----Remainder of the model is the same as MYPRIVT1-----
```

Model Report

The initial result of running MYPRIVT2 is the same as MYPRIVT1. Sorghum and peanuts continue to be the crops in the optimal solution; the inclusion of new possibility for growing corn has not affected the solution. To see the impact of factor substitution, reduce the amount of labor available. For example, setting the labor availability scalar to half its value, e.g. 8 man months produces the report shown below. Why does an increase in labor scarcity bring corn into the cropping pattern? Why has does the optimal cropping pattern continue to include some sorghum?

```
REPORT ON MYPRIVT2 SOLUTION  (Labor availability set at 8 man months.)
E X E C U T I N G

----    107 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE
OBJECTIVE 8731.727

----    107 PARAMETER ACTREP        VARIABLES SUMMARY

            CORNHAND    CORNMULE       BEANS      SORGHUM      PEANUTS
GROSSREV    2250.000    2250.000    2250.000    2015.000    6881.000
INPUTCO      875.000     875.000    1035.000     495.000    2015.000
NETREV      1375.000    1375.000    1215.000    1520.000    4866.000
LEVEL                      3.932                   0.559       0.509
RCOSTS      -313.200                -290.500

----    107 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY

LAND  5.000,    LABOR 8.000,    MULES 7.088

----    107 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES

LAND  963.200,    LABOR 290.000
```

INCORPORATING DIMINISHING RETURNS

The assumption that the output of a crop is a linear function of the resources used in its production has long been a criticism of l.p. methods. Just as in the case where there are only a limited number of constraints or technologies, responses to relative price and factor endowment changes under these conditions are often abrupt and "unrealistic."

As H-N (pp. 37-41) note, however, where data are available, it is relatively easy to incorporate the phenomenon of diminishing returns to more intensive input use. Again, the mechanism is to treat different levels of input use as different activities. Unlike the pure technologies case discussed earlier, however, each of the corn activities now has associated with it a yield commensurate with the amount of the input that is being applied. Assume, for example, that the letters shown in H-N's Figure 3.6 are replaced with the numbers shown below. (The yields associated with various levels of weeding labor are also shown in Figure 3.1.)

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE
YIELDS (KGS/HA)	450	750	825	860	750
WEEDING LABOR (MONTHS)	0	.7	1.4	2.1	.5
TOTAL LABOR (MONTHS)	1.1	1.8	2.5	3.2	1.4

Adding Diminishing Returns to the Model (MYPRIVT3)

Create a new model, MYPRIVT3, by making a copy of MYPRIVT2.

```
$TITLE            MYPRIVT3 BASIC MAYALAND MODEL AT PRIVATE PRICES
$OFFSYMXREF OFFSYMLIST
OPTION LIMCOL=0, LIMROW=0, SOLPRINT=OFF

SETS   J      CROPS     /CORNNW, CORNL1, CORNL2, CORNL3, CORNMULE,
                          BEANS, SORGHUM, PEANUTS/
       I      INPUTS    /FERT, PEST, CORNSEED, BEANSEED, SORGSEED, PEASEED/

PARAMETERS

  YIELDS(J)  YIELDS OF CROP ACTIVITIES (KGS PER HECTARE)
             /CORNNW 450, CORNL1 750, CORNL2 825, CORNL3 860, CORNMULE 750,
              BEANS 375, SORGHUM 775, PEANUTS 983/

  PROUTP(J)  PRICES OF CROP OUTPUT (PESOS PER KG)
             /CORNNW 3, CORNL1 3, CORNL2 3, CORNL3 3, CORNMULE 3,
              BEANS  6, SORGHUM 2.6, PEANUTS 7/
```

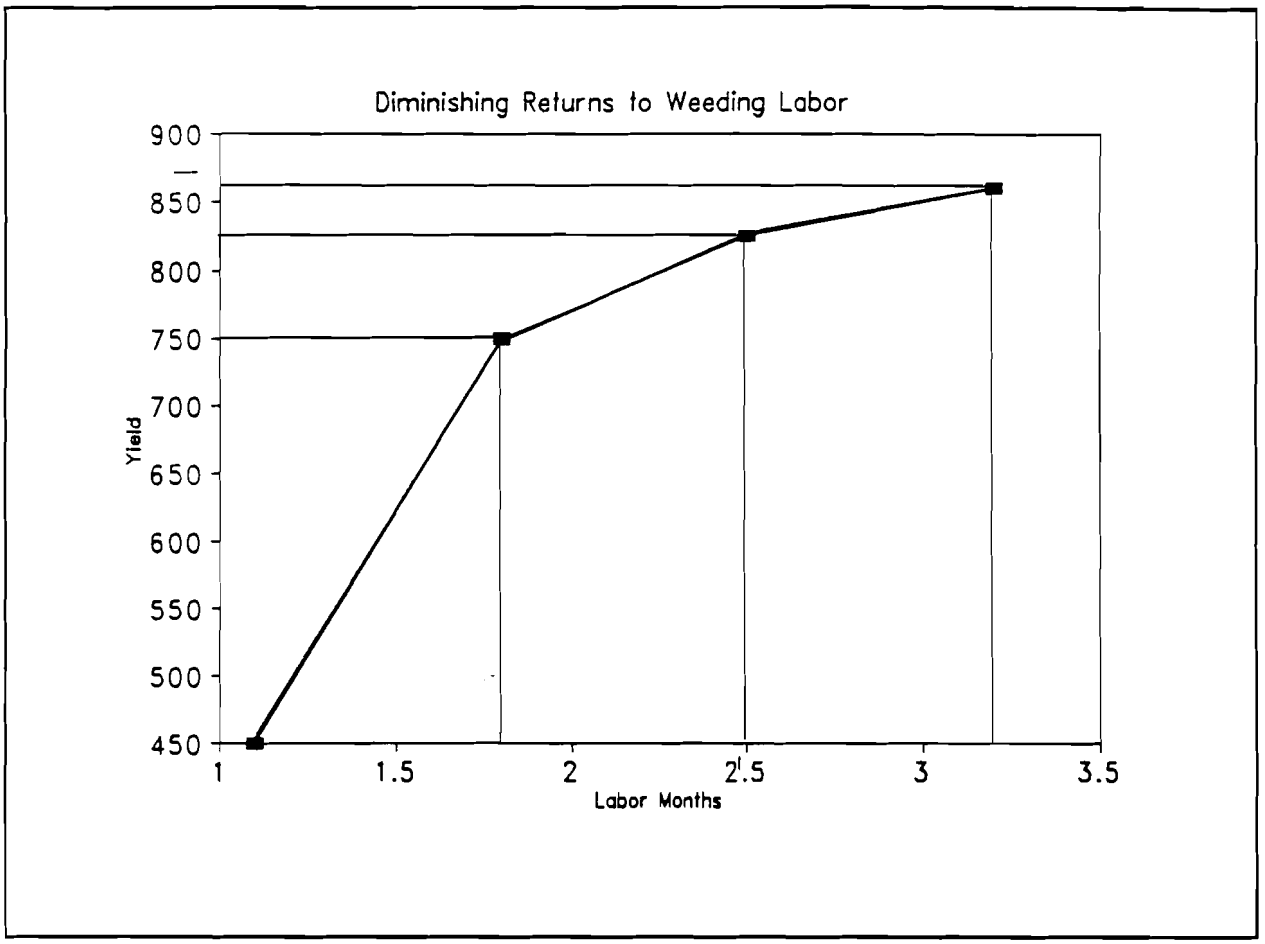


Figure 3.1

```
PRINP(I)   PRICES OF INPUTS (PESOS PER KG)
         /FERT 14, PEST 300,CORNSEED 5, BEANSEED 8, SORGSEED 5, PEASEED 9/

LAND(J)    LAND USE (HECTARES)
           /CORNNW 1, CORNL1 1, CORNL2 1, CORNL3 1, CORNMULE 1,
           BEANS 1,  SORGHUM 1,  PEANUTS 1/

LABOR(J)   LABOR USE (MAN MONTHS PER HECTARE)
          /CORNNW 1.1, CORNL1 1.8, CORNL2 2.5, CORNL3 3.2, CORNMULE 1.42,
          BEANS 1.87, SORGHUM 1.92, PEANUTS 2.64/

MULES(J)   MULE USE (PESOS PER HECTARE)
         /CORNNW 1, CORNL1 1, CORNL2 1, CORNL3 1, CORNMULE 1.45,
           BEANS 1.27, SORGHUM 1.16, PEANUTS 1.45/
```

```
  MP(J)       PEANUT YIELD FOR MARKET CONSTRAINT ON PEANUTS (KGS PER HA)
              /PEANUTS 983/

TABLE IN(I, J) INPUT USE (KGS PER HECTARE)

           CORNNW  CORNL1  CORNL2  CORNL3  CORNMULE   BEANS  SORGHUM  PEANUTS
FERT          50      50      50      50        50      40       30       70
PEST         .25     .25     .25     .25       .25     .25                .6
CORNSEED     20      20      20      20        20
BEANSEED                                                50
SORGSEED                                                         15
PEASEED                                                                   95
              -----Remainder of model is the same as MYPRIVT2-------
-------------------------------------------------------------------------------
```

The initial value of the objective function for MYPRIVT3 is greater than the value for MYPRIVT1. This is because the single yield level for corn used in MYPRIVT1 is equal to CORNL2, i.e., corn at level or step 2, of the MYPRIVT3 model. As Figure 3.1 shows, the highest corn yields exceed the level 2 yields by 110 kgs/hectare. This increase in yield is sufficient to increase the gross margins of corn to the point where it replaces sorghum in the optimal cropping pattern.

The impact of diminishing returns to labor in this version of MYPRIVT can be observed if some modest changes are made in the model. In GAMS, both scalars and parameters can be changed although the notation is slightly different. As demonstrated in the example below, just type in the new value and repeat the SOLVE statement.

To get a complete report on the output at new parameter or scalar values, the statements that produced the desired information in the original report generator must be repeated. Use NE's block copying facility (F4,S to set the block, F4, C to copy it.) to reproduce the report generator as shown in the example. Do not repeat the sets and parameters definitions that were used to introduce the original report equations. (Parametric variation is dealt with in detail in Chapter 4.)

Immediately beneath the DISPLAY statement of the report generator, type (and copy) the following lines. (The output is shown below.)

```
*-------------------------------------------------------------------------------
   AMTLAB             =   12 ;
   PROUTP("SORGHUM") =   2.4 ;
   SOLVE MYPRIVT3 USING LP MAXIMIZING Z;

     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =   SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)- ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =   CROPS.L(J);
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);
```

The last statement produces the "reduced costs" for each crop and is the answer to the questions regarding extensions of the report writer posed earlier in the chapter. Reduced costs described the decline in the objective function that would occur if one unit of the enterprise was forced into the optimal solution.

```
     OBJFUN("OBJECTIVE")        =     Z.L;

     CONREP("LAND")             =     SUM(J, CROPS.L(J)*LAND(J));
     CONREP("LABOR")            =     SUM(J, CROPS.L(J)*LABOR(J));
     CONREP("MULES")            =     SUM(J, CROPS.L(J)*MULES(J));

     CONMARG("LAND")            =     CONSTL.M;
     CONMARG("LABOR")           =     CONSTLA.M;
     CONMARG("MULES")           =     CONSTMUL.M;

  DISPLAY OBJFUN, ACTREP, CONREP, CONMARG;
```

Output From The Diminishing Returns Model

The new solution when labor is set to 12 instead of 16.5 and the price of sorghum is set to 2.4 pesos per kilo instead of 2.6 is shown below. In addition to the information on costs and returns, the levels of the activities and the "marginals" for the resource constraints, the report also contains information on the "reduced cost" of the activities. This information is useful in assessing the distance that non-optimal activities are from being included in the optimal solution. For example, in the solution based on 12 man months of labor and a sorghum price of 2.4, it is clear from the reduced costs that the next candidate for inclusion in the optimal basis is sorghum.

Comparison of the revised MYPRIVT3 solution with the solution using the original parameters indicates that the selection by the model of steps on the production function below the maximum yield reflects not only the increasing scarcity of labor, but also the reduction in the comparative advantage of sorghum as a result of the decline in its price.

```
----    139 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE

OBJECTIVE  9542.239

----    139 PARAMETER ACTREP        VARIABLES SUMMARY

                CORNNW      CORNL1      CORNL2      CORNL3     CORNMULE

GROSSREV     1350.000    2250.000    2475.000    2580.000    2250.000
INPUTCO       875.000     875.000     875.000     875.000     875.000
NETREV        475.000    1375.000    1600.000    1705.000    -875.000
```

```
LEVEL                                    3.962                    .529
REDCOSTS    -833.333     -79.167                  - 40.833

       +       BEANS     SORGHUM     PEANUTS

GROSSREV    2250.000    1860.000    6881.000
INPUTCO     1035.000     495.000    2015.000
NETREV      1215.000    1365.000    4866.000
LEVEL                                   0.509
REDCOSTS    -253.750    -144.167

----    139 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY

LAND   5.000,    LABOR 12.000,    MULES  5.467

----    139 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES

LAND  1079.167,    LABOR 208.33

-----------------------------------------------------------------------
```

Further disaggregation of cropping activities may be desirable along the lines suggested in the section in H-N dealing with differences in the quality of resources. In the case of irrigated vs. non-irrigated, if all crops could be grown on both types of land, new activities would have to be constructed for each. Each, however, would have common labor and mule rows indicating that, while they were grown in distinctly different environments, all continued to compete for a limited amount of human and animal power.

Disaggregation by labor type also can be important. More interesting than the H-N suggestion regarding a division of labor in crop production is the highly prevalent disaggregation of labor in livestock production. Livestock and livestock products are important in almost all developing country agricultures and, except in pastoral settings, animals usually are cared for by women and children.

SEASONALITY IN FARMING SYSTEMS MODELS

Seasonality is a major determinant of comparative advantage in most agricultural systems. It is particularly important in arid and semi-arid irrigated environments where year-around cropping is possible and planting and harvesting between seasons often creates extensive land, labor, and draught power bottlenecks.

Hazell and Norton provide coefficients on page 43 that make it possible to enrich the constraint set of the Mayaland model with data on the seasonal use of land, labor, and animal power. The previous extension to include diminishing returns of labor to corn weeding has been maintained, and

labor coefficients for May and June have been adjusted accordingly. Lessor adjustments have been made to harvesting and corn shelling coefficients to reflect increased yields.

On page 44, H-N develop a further consideration of seasonality--the staggering of planting and harvesting dates. This is an important device that farmer's use to avoid seasonal bottlenecks. Note that seasonal information can be entered selectively, i.e., not all months need be represented nor do the time periods have to be the same for different constraints. If alternative planting dates were added to each of the already existing activities, it would produce 15 different ways of producing corn (5 technologies x 3 planting dates). Although additional activities add realism to the modeling of farmer decisions and columns are relatively inexpensive computationally, it is obvious that some care needs to be exercised so that the multiplication of technologies does not to make the model unwieldy.

The first step in developing a new model to carry out the seasonal exercise is to make a copy of MPRIVT3 with the command: COPY MYPRIVT3 MYPRIVT4, and add the information shown below to the model. Use the methods described in the following paragraph. Note also the places in which a seasonal index must be introduced in the model in order for the computations to be made correctly.

Adding seasonal information to a GAMS model can be facilitated by using block and copy commands. After adding the appropriate seasonal index to the model, one table showing crops as activities and months as constraints will need to be constructed. It probably is best to enter the data for land use in the table in order to provide a check on the accurate placement of data in the following labor table. Once the land table has been completed, use NE's block and copy commands (F4 S at both ends of the table, F4 C to copy it at the cursor) as described earlier. When entering data, first type F6 Insert in order to put the editor in "replace" or typeover mode. The new data then can be entered by typing over the existing data thus minimizing the number of deletions.)

GAMS Model with Seasons (MYPRIVT4)

```
------------------------------------------------------------------------

$TITLE          MYPRIVT4 BASIC MAYALAND MODEL AT PRIVATE PRICES
*               (Adding seasonality to the MYPRIVT model)

$OFFSYMXREF OFFSYMLIST
OPTION LIMROW=0, LIMCOL=0, SOLPRINT=OFF

SETS   J     CROPS     /CORNNW, CORNL1, CORNL2, CORNL3, CORNMULE,
                         BEANS, SORGHUM, PEANUTS/
       I     INPUTS    /FERT, PEST, CORNSEED, BEANSEED, SORGSEED, PEASEED/
       S     SEASONS   /JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG,
                         SEP, OCT, NOV, DEC/

PARAMETERS
```

```
  YIELDS(J)  YIELDS OF CROP ACTIVITIES (KGS PER HECTARE)
             /CORNNW 450, CORNL1 750, CORNL2 825, CORNL3 860, CORNMULE 750,
              BEANS 375, SORGHUM 775, PEANUTS 983/

  PROUTP(J)  PRICES OF CROP OUTPUT (PESOS PER KG)
             /CORNNW 3, CORNL1 3, CORNL2 3, CORNL3 3, CORNMULE 3,
              BEANS  6, SORGHUM 2.6, PEANUTS 7/

  PRINP(I)   PRICES OF INPUTS (PESOS PER KG)
            /FERT 14, PEST 300,CORNSEED 5, BEANSEED 8, SORGSEED 5, PEASEED 9/

  MULES(J)   MULE USE (PESOS PER HECTARE)
           /CORNNW 1, CORNL1 1, CORNL2 1, CORNL3 1, CORNMULE 1.45,
            BEANS 1.27, SORGHUM 1.16, PEANUTS 1.45/

  MP(J)      PEANUT YIELD FOR MARKET CONSTRAINT ON PEANUTS (KGS PER HA)
             /PEANUTS 983/
```

TABLE IN(I, J) INPUT USE (KGS PER HECTARE)

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS	SORGHUM	PEANUTS
FERT	50	50	50	50	50	40	30	70
PEST	.25	.25	.25	.25	.25	.25		.6
CORNSEED	20	20	20	20	20			
BEANSEED						50		
SORGSEED							15	
PEASEED								95

TABLE LAND(S, J) LAND USE (HECTARES)

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS	SORGHUM	PEANUTS
JAN								
FEB						1		
MAR						1		
APR	1	1	1	1	1	1		1
MAY	1	1	1	1	1	1	1	1
JUN	1	1	1	1	1		1	1
JUL	1	1	1	1	1		1	1
AUG							1	1
SEP								
OCT								
NOV								
DEC								

TABLE LABOR(S, J) LABOR USE (MAN MONTHS PER HECTARE)

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS	SORGHUM	PEANUTS
JAN								
FEB						.27		

MAR						.36		
APR	.27	.27	.27	.27	.27	.50		.36
MAY	.16	.46	.76	1.06	.46	.50	.32	.36
JUN	.16	.46	.76	1.06	.46		.36	.27
JUL	.09	.09	.19	.19	.09		.50	.64
AUG							.50	.55
SEP	.08	.18	.18	.24	.18			
OCT	.26	.36	.36	.40	.36			
NOV							.24	.46
DEC								

* Labor used in September, October and November represent shelling and *threshing hours.

```
SCALARS

      AMTLAND  AMOUNT OF LAND AVAILABLE (HECTARES)      /5/
      AMTLAB   AMOUNT OF LABOR AVAILABLE (BY MONTH)    /1.375/
      AMTMULE  MULE POWER AVAILABLE (MONTHS)           /10/
      MARKET   MARKET CONSTRAINT ON PEANUTS(KGS)       /500/

VARIABLES
            REVENUE    GROSS REVENUE FROM CROP ACTIVITIES
            COST       TRADABLE INPUT COSTS
            CROPS      LEVELS OF THE CROP ACTIVITIES
            Z          TOTAL VALUE ADDED FROM CROP ACTIVITIES
                      POSITIVE VARIABLES CROPS

EQUATIONS

       REV            COMPUTATION OF GROSS REVENUES
       INCOST         COMPUTATION OF TRADABLE INPUT COSTS
       CONSTL(S)      LAND CONSTRAINT
       CONSTLA(S)     LABOR CONSTRAINT
       CONSTMUL       MULE CONSTRAINT
       MARKT          MARKET CONSTRAINT ON PEANUTS
       OBJFN          OBJECTIVE FUNCTION;

       REV..      REVENUE -E- SUM(J,YIELDS(J)*PROUTP(J)*CROPS(J));
       INCOST..   COST    -E- SUM((I, J), IN(I,J)*PRINP(I)*CROPS(J));
       CONSTL(S)..              SUM(J, LAND(S,J)*CROPS(J)) -L-AMTLAND;
       CONSTLA(S)..             SUM(J, LABOR(S,J)*CROPS(J)) -L-AMTLAB;
       CONSTMUL..               SUM(J, MULES(J)*CROPS(J)) -L-AMTMULE;
       MARKT..                  SUM(J, MP(J)* CROPS(J)) -L-MARKET;
       OBJFN..       Z -E- REVENUE-COST;

MODEL MYPRIVT4/ALL/;
SOLVE MYPRIVT4 USING LP MAXIMIZING Z;

$TITLE                  REPORT ON MYPRIVT4 SOLUTION
```

```
SETS     AREP     /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
         CREP     /LAND, LABOR, MULES/
         OBJ      /OBJECTIVE/

PARAMETERS     ACTREP    VARIABLES SUMMARY
               CONREP    DOMESTIC RESOURCE USE SUMMARY
               CONMARG   SHADOW PRICES OF DOMESTIC RESOURCES
               OBJFUN    OBJECTIVE FUNCTION VALUE;

ACTREP("GROSSREV", J)   =   YIELDS(J)*PROUTP(J);
ACTREP("INPUTCO", J)    =  SUM(I, IN(I, J)*PRINP(I));
ACTREP("NETREV", J)     =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
ACTREP("LEVEL",J)       =  CROPS.L(J);
ACTREP("REDCOSTS",J)    =   CROPS.M(J);

OBJFUN("OBJECTIVE")        =     Z.L;


CONREP(S,"LAND")           =     SUM(J, CROPS.L(J)*LAND(S,J));
CONREP(S,"LABOR")          =     SUM(J, CROPS.L(J)*LABOR(S,J));
CONREP(S,"MULES")          =     SUM(J, CROPS.L(J)*MULES(J));
```

A seasonal dimension for mule resources is required if the results are to be reported in the same table as land and labor. The present statement reproduces the annual levels in each month. The same tactic has been used to report the shadow prices of mule labor below.

```
CONMARG(S,"LAND")          =     CONSTL.M(S);
CONMARG(S,"LABOR")         =     CONSTLA.M(S);
CONMARG(S,"MULES")         =     CONSTMUL.M;

DISPLAY OBJFUN, ACTREP, CONREP, CONMARG;
```

The tables represented by CONREP (Constraint Report) and CONMARG (Constraint Marginals) are currently inconsistent because the dimensions of the tables differ by type of constraint. For example, land and labor now have a seasonal dimension but mules do not. As GAMS error messages rightly note, this won't work. The best compromise, short of defining tables describing monthly mule use, is to tell GAMS to repeat the figure for the single annual constraint in each month. This has been done in the report generator shown above. The same value for mule power used will appear in each month although it represents the value of annual use. (The problem would be eliminated, of course, if you were to develop a seasonal mule labor table. If you do, be sure to add the seasonal index to the right hand side of the mule equations in the report generator.)

Results of Adding Seasonality

The impact of adding seasonal constraints is substantial. The cropping pattern is now determined by the monthly competition for labor rather than by the competition for land. For example, both corn and sorghum appear in the cropping pattern because, in the critical month of July when the high-valued peanuts use substantial amounts of labor, corn uses relatively less labor than sorghum. Including diminishing returns to weeding has a more focused impact when it is incorporated in a seasonal model than when weeding labor is part of a total labor aggregate. Virtually the entire effect of diminishing returns to labor has been implemented by adjusting the labor coefficients for May and June, the principal weeding months.

REPORT ON MYPRIVT4 SOLUTION (1.375 MAN MONTHS AVAILABLE PER MONTH)

---- 141 PARAMETER OBJFUN OBJECTIVE FUNCTION VALUE

OBJECTIVE 7080.332

---- 141 PARAMETER ACTREP VARIABLES SUMMARY

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE
GROSSREV	1350.000	2250.000	2475.000	2580.000	2250.000
INPUTCO	875.000	875.000	875.000	875.000	875.000
NETREV	475.000	1375.000	1600.000	1705.000	1375.000
LEVEL		1.220			
REDCOSTS	-77.198		-723.769	-1441.571	

+	BEANS	SORGHUM	PEANUTS
GROSSREV	2250.000	2015.000	6881.000
INPUTCO	1035.000	495.000	2015.000
NETREV	1215.000	1520.000	4866.000
LEVEL	0.059	1.879	0.509

---- 141 PARAMETER CONREP DOMESTIC RESOURCE USE SUMMARY

	LAND	LABOR	MULES
JAN			4.212
FEB	0.059	0.016	4.212
MAR	0.059	0.021	4.212
APR	1.787	0.542	4.212
MAY	3.667	1.375	4.212
JUN	3.608	1.375	4.212
JUL	3.608	1.375	4.212
AUG	2.388	1.219	4.212
SEP		0.220	4.212
OCT		0.439	4.212
NOV		0.685	4.212
DEC			4.212

```
----    141 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES
          LABOR
MAY     2430.000
JUN      312.672
JUL     1259.676
```

After you have copied the land and labor tables into the GAMS code and debugged the model, try adding a seasonal mule table on your own. You will have to make up the data, but you do have some guidance from the existing labor coefficients, i.e., mules can't work without drivers. However, you will have to make adjustments to account for the fact that the corn technologies have seasonally different labor and mule demands. Remember also that the "mule months" scalar will need to be adjusted to reflect monthly, not annual, availability

Try relaxing the labor constraint by typing in a higher value for the labor scalar. Does seasonality become more or less important as labor availability increases? How would the results of policy experiments differ in the seasonal vs. the non seasonal model? Inspect the technical coefficient tables and speculate on the effect of adding the alternative planting dates for corn given in H-N, p. 44. Without actually doing the exercise, try to imagine the likely impact of making these further adjustments in seasonality to the model.

CHAPTER 4: DERIVING NORMATIVE DEMAND AND SUPPLY CURVES

Even a casual acquaintance with l.p. modeling suggests that much of the benefit of constructing and running models is obtained by "playing" with the model. Often the lack of data, along with the limitations in model specifications, make specific answers to a farming systems problems suspect. However, considerable insight can be gained into the working of a farming system by parametrically altering various parameters and observing the behavior of the model. Along with systematic data organization, the sharpening of intuition about a particular agro-climatic area is one of the most important benefits of model construction.

Commercial optimization packages such as IBM's MPS series permit the systematic variation of parameters and the reporting of every basis changes that occurs. GAMS does not, and this is a limitation of the current versions of the software. However, something similar can be accomplished by using a sequence of assignment and SOLVE statements. Using this technique, the two examples that follow show how (1) demand curves for inputs or factors can be derived and (2) supply curves for outputs can be generated.

Begin at the DOS prompt with: COPY MYPRIVT4 MYDEM1. This produces a copy of the last model developed in Chapter 3. The new model will be used to produce a demand curve for labor. COPY MYPRIVT4 MYSUP1 will produce a version of MYPRIVT4 that will be used to generate a supply curve for sorghum.

DERIVING A DEMAND CURVE FOR RESOURCES

The techniques needed to derive a demand curve for resources have been indicated previously as a part of the discussion of sensitivity analysis. Producing the output required to plot a curve merely requires repeated application of the same methods. The sequence of commands shown below can be used to generate the data for a labor demand curve. It can be implemented immediately following the SOLVE statement in the original (MYDEM1) problem.

If only information on the parameters required to plot the graph is desired, the lines following the SOLVE statement might be confined to lines that displayed the amount of labor and the resulting sum of the resource marginals. However, much that is of interest, e.g., changes in the cropping pattern and changes in other resource marginals, would be lost. Hence, it is desirable to reproduce the report generator for each new value of the resource availability scalar.

The desired report generator is indicated below for the first two values of the scalar, AMTLAB. To produce the entire input file from the original MYDEM1 file, use the "block" and "copy" commands of the text editor (F4, S and F4, C) to produce the first step, modify it as indicated, then copy for each remaining step. Once the steps have been copied, edit them to produce different values for AMTLAB. (Remember to modify the name of the model definition statement to MYDEM1.)

Add SUMM to the list of the report generator's parameters. It should now read:

```
     PARAMETERS    ACTREP    VARIABLES SUMMARY
                   CONREP    DOMESTIC RESOURCE USE SUMMARY
                   CONMARG   SHADOW PRICES OF DOMESTIC RESOURCES
                   OBJFUN    OBJECTIVE FUNCTION VALUE
                   SUMM      SUM OF LABOR MARGINALS;
```

The following sequence produces a series of scalar changes for monthly labor availability that will be used to chart out the labor demand curve. The first two steps, .5 and 1, are shown below. Continue at .5 step intervals to 3.0. (What do you already know about the demand curve for labor at 1.35?) Use of the block and copy facilities in NE make the seemingly formidable task of creating multiple solutions quite simple. The only things that needs to be changed in each version is the value of the scalar for labor.

```
AMTLAB = .5;
SOLVE MYDEM1 USING LP MAXIMIZING Z;
     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =  CROPS.L(J);
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);

     OBJFUN("OBJECTIVE")         =     Z.L;

     CONREP(S,"LAND")            =     SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")           =     SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")           =     SUM(J, CROPS.L(J)*MULES(J));

     CONMARG(S,"LAND")           =     CONSTL.M(S);
     CONMARG(S,"LABOR")          =     CONSTLA.M(S);
     CONMARG(S,"MULES")          =     CONSTMUL.M;
```

The statements below sum over the shadow prices of the seasonal constraints. Be sure that SUMM has been added previously to the list of the report generator's parameters.

```
     SUMM("TOTALLA")             =     SUM(S, CONSTLA.M(S));
     SUMM("TOTALLN")             =     SUM(S, CONSTL.M(S));

DISPLAY AMTLAB,SUMM,OBJFUN, ACTREP, CONREP, CONMARG;

AMTLAB = 1;
SOLVE MYDEM1 USING LP MAXIMIZING Z;
     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
```

```
     ACTREP("LEVEL",J)        =  CROPS.L(J);
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);

     OBJFUN("OBJECTIVE")         =      Z.L;

     CONREP(S,"LAND")            =      SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")           =      SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")           =      SUM(J, CROPS.L(J)*MULES(J));

     CONMARG(S,"LAND")           =      CONSTL.M(S);
     CONMARG(S,"LABOR")          =      CONSTLA.M(S);
     CONMARG(S,"MULES")          =      CONSTMUL.M;

     SUMM("TOTALLA")               =      SUM(S, CONSTLA.M(S));
     SUMM("TOTALLN")               =      SUM(S, CONSTL.M(S));

DISPLAY AMTLAB,SUMM,OBJFUN, ACTREP, CONREP, CONMARG;
```

Results of the Sensitivity Analysis

Figure 4.1 is a plot of the amount of labor available each month against the seasonally summed shadow price of one unit of additional annual labor. The graph indicates clearly how sensitive the model is to assumptions about labor availability. The rapid decline in labor's shadow price is accompanied by an equally rapid increase in the value of the objective function.

DERIVING A SUPPLY CURVE FOR OUTPUTS

Deriving a normative supply curve for sorghum proceeds in much the same way as deriving the demand curve for labor. In this case, however, the number to be varied is part of the parameter PROUTP and hence must be identified as such. The first two iterations are displayed below. Again, it would have been possible to isolate only the desired parameter by simplifying the report generator.

```
PROUTP("SORGHUM") = 1;
SOLVE MYSUP1 USING LP MAXIMIZING Z;
     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =  CROPS.L(J);
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);

     OBJFUN("OBJECTIVE")         =      Z.L;
     CONREP(S,"LAND")            =      SUM(J, CROPS.L(J)*LAND(S,J));
```

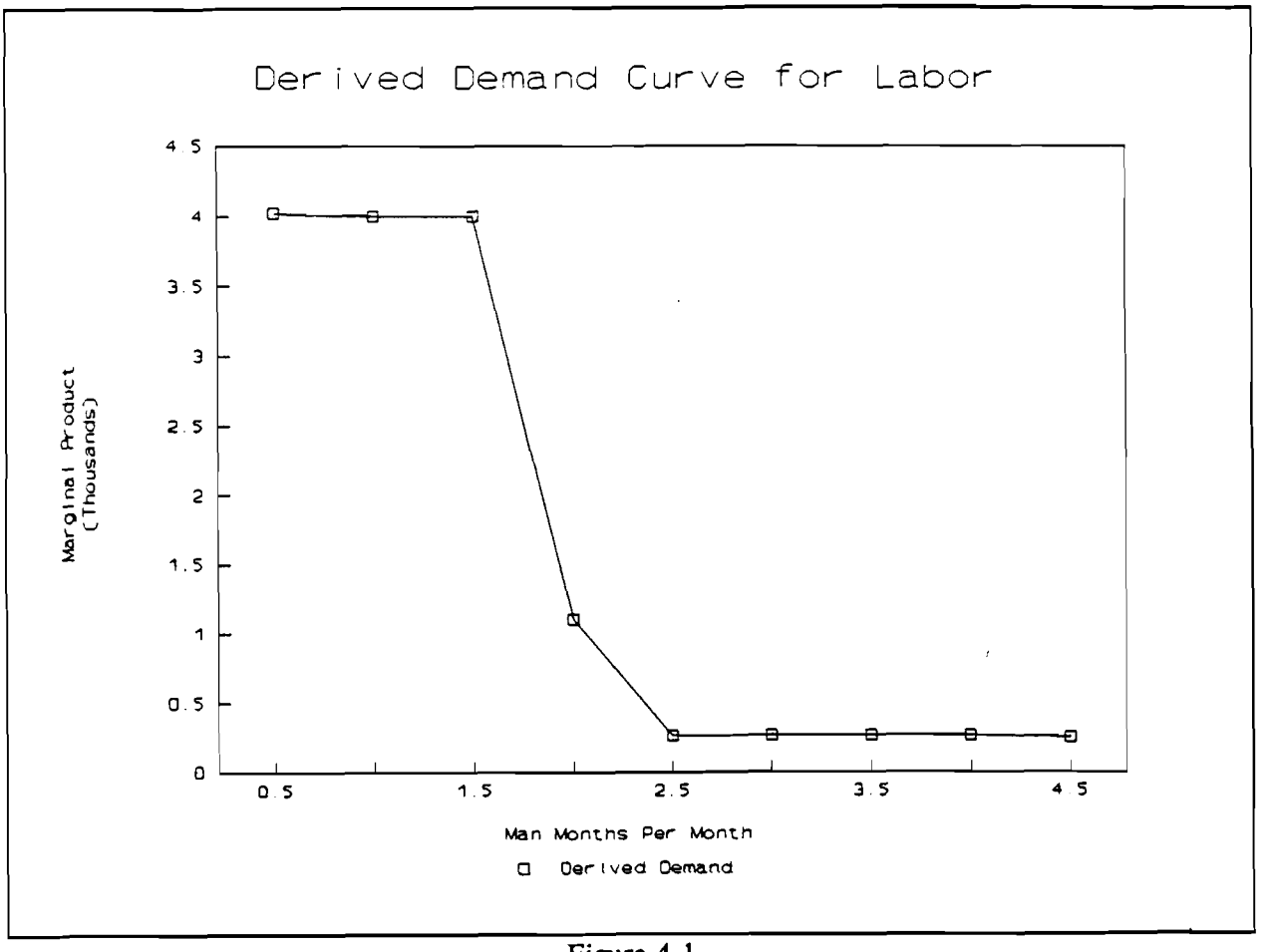


Figure 4.1

```
     CONREP(S,"LABOR")          =      SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")          =      SUM(J, CROPS.L(J)*MULES(J));

     CONMARG(S,"LAND")          =      CONSTL.M(S);
     CONMARG(S,"LABOR")         =      CONSTLA.M(S);
     CONMARG(S,"MULES")         =      CONSTMUL.M;

DISPLAY PROUTP,OBJFUN, ACTREP, CONREP, CONMARG;

PROUTP("SORGHUM") = 2;
SOLVE MYSUP1 USING LP MAXIMIZING Z;
     ACTREP("GROSSREV", J)    =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)     =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)      =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)        =  CROPS.L(J);
```

```
     ACTREP("REDCOSTS",J)     =   CROPS.M(J);

     OBJFUN("OBJECTIVE")        =     Z.L;

     CONREP(S,"LAND")           =     SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")          =     SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")          =     SUM(J, CROPS.L(J)*MULES(J));
     CONMARG(S,"LAND")          =     CONSTL.M(S);
     CONMARG(S,"LABOR")         =     CONSTLA.M(S);
     CONMARG(S,"MULES")         =     CONSTMUL.M;

DISPLAY PROUTP,OBJFUN, ACTREP, CONREP, CONMARG;
```

Results of the Sensitivity Analysis

Figure 4.2 shows the results of the parametric variation of sorghum prices. As would be expected with so few constraints, basis changes are relatively infrequent and the optimal solutions do not trace out a smooth curve. The result is a highly inelastic supply response over substantial sorghum prices ranges and extreme sensitivity at other points. It is reminiscent of the two dimension model described in Chapter 1. The need for a richer model with a more complete technical matrix and additional crop activities is obvious.

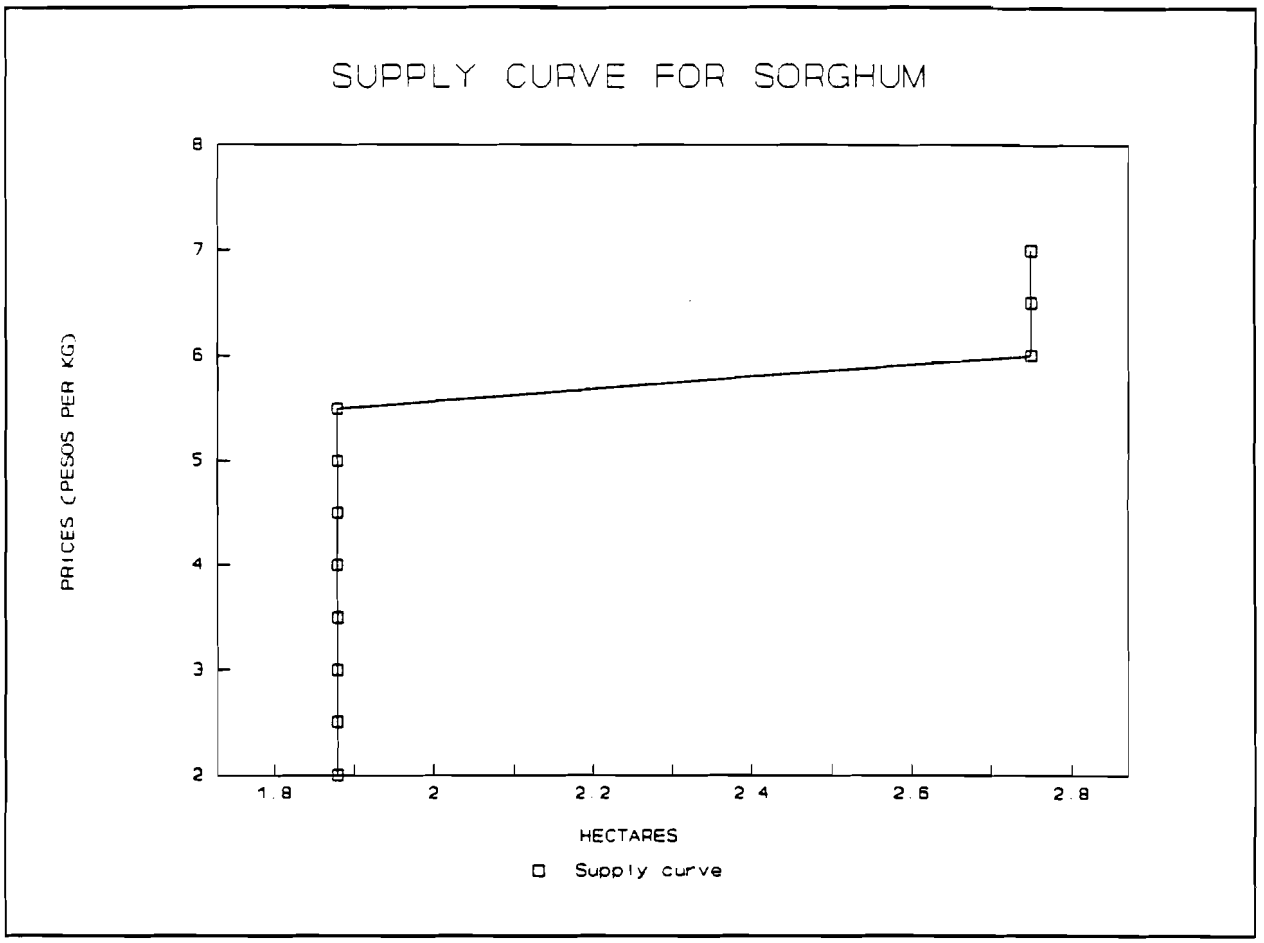

SUPPLY CURVE FOR SORGHUM
PRICES (PESOS PER KG)
8
7
6
5
4
3
2
1.8
2
2.2
2.4
2.6
2.8
HECTARES
Supply curve

Figure 4.2

CHAPTER 5: POLICY ANALYSIS: ADDING SOCIAL PRICES

In the Monke-Pearson PAM framework, policy interventions are associated primarily with divergences between the private and social prices of tradable outputs and inputs.[2] Private prices are those observed in domestic markets; social prices are the domestic equivalents of the international prices of tradable commodities. The latter represent the true opportunity cost of tradables to the economy. The significance of calculating optimal resource use when gross margins are computed using international prices is that the resulting cropping pattern contains those commodities in which the economy has a comparative advantage.

In the world of partial budgets, the impact of using social prices is often overstated because no adjustments of factor use to price changes is assumed. This assumption can be relaxed in the l.p. framework. The result is that judgments about the effects of policy reforms on farming systems tend to be less dramatic than when partial budgeting methods are employed.

The GAMS model below shows how a new set of (social) prices can be incorporated in the analysis with a minimum of effort. The strategy relies on reusing most of the constraints in the private prices model, namely, those relating to physical input-output constraints. Once the parameters describing output and input prices have been changed, only those equations that compute revenues and costs need be repeated. The model's definition statement, instead of specifying all constraints (/ALL/) as was the case in previous exercises, now ennumerates each constraint individually. *Both models are contained in the same MYPOLICY file and will be run consecutively by GAMS.*

COMPUTING AN OPTIMAL SOLUTION AT SOCIAL PRICES

To add social prices to the MYPRIVT4 model used in Chapter 3, first copy MYPRIVT4 to a file called MYPOLICY. Add the following section below the DISPLAY statement of the MYPRIVT4 report generator in the newly created MYPOLICY model.

```
---------------------------------------------------------------------
 $TITLE         OPTIMAL SOLUTION WITH SOCIAL PRICES

PARAMETERS

  SOOUTP(J)  PRICES OF CROP OUTPUT (PESOS PER KG)
            /CORNNW 2.5, CORNL1 2.5, CORNL2 2.5, CORNL3 2.5, CORNMULE 2.5,
             BEANS  12, SORGHUM 3.2, PEANUTS 5/

  SOINP(I)   PRICES OF INPUTS (PESOS PER KG)
           /FERT 28, PEST 450,CORNSEED 4, BEANSEED 14, SORGSEED 4, PEASEED 7/
```

[2] Chapter 1-2 are assigned reading.

The prices shown in the newly created parameter statements are assumed to reflect the domestic equivalents of international prices. Note that the names of the parameters have been changed.

```
EQUATIONS
            REVSO          REVENUE COMPUTATION AT SOCIAL PRICES
            INCOSTSO       COST COMPUTATION AT SOCIAL PRICES;

        REVSO..       REVENUE =E= SUM(J, YIELDS(J)*SOOUTP(J)*CROPS(J));
        INCOSTSO..    COST    =E= SUM((I,J), IN(I,J)*SOINP(I)*CROPS(J));
```

The above equations compute gross revenues and variable costs using parameters that describe social prices. The model definition statement shown below ennumerates each equation in the model. The new model has been called MYSOCIAL to distinguish it from the MYPRIVT4 model that makes up the first part of the MYPOLICY file.

```
MODEL MYSOCIAL /REVSO, INCOSTSO, CONSTL, CONSTLA, CONSTMUL, MARKT, OBJFN/;
SOLVE MYSOCIAL USING LP MAXIMIZING Z;
```

The report generator for the social prices model follows directly after the SOLVE statement. Again, remember to use NE's block and copy facility to convert the private prices report generator to the social prices report generator.

```
$TITLE                  REPORT ON MYSOCIAL SOLUTION
```

Note that the letter S has been added to the SET and PARAMETER names. The set elements need not be changed to distinguish between the results of the private and social solutions.

```
    SETS      AREPS     /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
              CREPS     /LAND, LABOR, MULES/
              OBJS      /OBJECTIVE/

    PARAMETERS     ACTREPS    VARIABLES SUMMARY
                   CONREPS    DOMESTIC RESOURCE USE SUMMARY
                   CONMARGS   SHADOW PRICES OF DOMESTIC RESOURCES
                   OBJFUNS    OBJECTIVE FUNCTION VALUE;

 ACTREPS("GROSSREV", J)   =  YIELDS(J)*SOOUTP(J);
 ACTREPS("INPUTCO", J)    =  SUM(I, IN(I, J)*SOINP(I));
 ACTREPS("NETREV", J)     =  ACTREPS ("GROSSREV", J)-ACTREPS("INPUTCO", J);
 ACTREPS("LEVEL",J)       =  CROPS.L(J);
 ACTREPS("REDCOSTS",J)    =  CROPS.M(J);

 OBJFUNS("OBJECTIVE")        =     Z.L;

 CONREPS(S,"LAND")           =     SUM(J, CROPS.L(J)*LAND(S,J));
```

```
  CONREPS(S,"LABOR")          =       SUM(J, CROPS.L(J)*LABOR(S,J));
  CONREPS(S,"MULES")          =       SUM(J, CROPS.L(J)*MULES(J));


   CONMARGS(S,"LAND")          =        CONSTL.M(S);
   CONMARGS(S,"LABOR")         =        CONSTLA.M(S);
   CONMARGS(S,"MULES")         =        CONSTMUL.M;

  DISPLAY OBJFUNS, ACTREPS, CONREPS, CONMARGS;
*---------------------------------------------------------------------
```

COMPARISON OF PRIVATE AND SOCIAL SOLUTIONS

The results of the private and social prices runs are reported below. They indicate clearly the significance of changes in relative prices of outputs and inputs in determining the optimal cropping pattern. Under social prices, beans are the dominant crop in the optimal cropping pattern. Note also, however, that neither the objective function nor the shadow prices of resources have changed much. A characteristic of farming systems models is that the primal tends to be more unstable and volatile than the dual. Why should this be so? Hint: When crops compete for the same resources, slight differences in relative profitability may produce a major change in the cropping pattern without affecting the marginal product of the scarce factors. The further implication, at least for the farming system being modeled, is that although price reforms might produce a significant change in the cropping pattern, there would be little impact on farmer's incomes.

Solution of MYPOLICY at Private Prices

```
---------------------------------------------------------------------------
----    141 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE

OBJECTIVE 7080.332

----    141 PARAMETER ACTREP        VARIABLES SUMMARY
              CORNNW      CORNL1      CORNL2      CORNL3     CORNMULE
GROSSREV    1350.000    2250.000    2475.000    2580.000    2250.000
INPUTCO      875.000     875.000     875.000     875.000     875.000
NETREV       475.000    1375.000    1600.000    1705.000    1375.000
LEVEL                     1.220
REDCOSTS     -77.198                -723.769   -1441.571         EPS

      +        BEANS     SORGHUM     PEANUTS

GROSSREV    2250.000    2015.000    6881.000
INPUTCO     1035.000     495.000    2015.000
NETREV      1215.000    1520.000    4866.000
LEVEL          0.059       1.879       0.509

----    141 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY
```

	LAND	LABOR	MULES
JAN			4.212
FEB	0.059	0.016	4.212
MAR	0.059	0.021	4.212
APR	1.787	0.542	4.212
MAY	3.667	1.375	4.212
JUN	3.608	1.375	4.212
JUL	3.608	1.375	4.212
AUG	2.388	1.219	4.212
SEP		0.220	4.212
OCT		0.439	4.212
NOV		0.685	4.212
DEC			4.212

---- 141 PARAMETER CONMARG SHADOW PRICES OF DOMESTIC RESOURCES

	LABOR
MAY	2430.000
JUN	312.672
JUL	1259.676

Solution to MYPOLICY at Social Prices

The change in relative prices is sufficient to drive all corn from the optimal cropping pattern under social prices. (Note that the net revenues of non-weeded corn are actually negative.) Does this suggest a rationale for the government subsidies? Hint: Suppose that the government, as a matter of national policy, wanted to maintain a certain amount of self-sufficiency in corn. What does the "reduced cost" report of the social prices solution say about the magnitude of the subsidies that would be required? Examine the distortions in the prices of other crops. What interpretation can be given to the motivation for government policies?

---- 193 PARAMETER OBJFUNS OBJECTIVE FUNCTION VALUE

OBJECTIVE 7147.807

193 PARAMETER ACTREPS VARIABLES SUMMARY

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE
GROSSREV	1125.000	1875.000	2062.500	2150.000	1875.000
INPUTCO	1592.500	1592.500	1592.500	1592.500	1592.500
NETREV	-467.500	282.500	470.000	557.500	282.500
REDCOSTS	-1310.825	-2042.075	-3335.825	-4729.575	-2042.075

+	BEANS	SORGHUM	PEANUTS
GROSSREV	4500.000	2480.000	4915.000
INPUTCO	1932.500	900.000	2895.000
NETREV	2567.500	1580.000	2020.000
LEVEL	2.384		0.509

```
----     193 PARAMETER CONREPS       DOMESTIC RESOURCE USE SUMMARY
            LAND       LABOR       MULES
JAN                                 3.765
FEB         2.384      0.644       3.765
MAR         2.384      0.858       3.765
APR         2.892      1.375       3.765
MAY         2.892      1.375       3.765
JUN         0.509      0.137       3.765
JUL         0.509      0.326       3.765
AUG         0.509      0.280       3.765
SEP                                 3.765
OCT                                 3.765
NOV                    0.234        3.765
DEC                                 3.765

----     193 PARAMETER CONMARGS      SHADOW PRICES OF DOMESTIC RESOURCES

            LABOR

APR       197.500
MAY      4937.500
```

COMPUTING CROPWISE PROTECTION COEFFICIENTS

Now that the report generators have produced calculations of gross revenues and variable costs at both private and social prices, it is a simple matter to write a GAMS routine that computes the NOPC (nominal output protection coefficient), the NIPC (nominal input protection coefficient) and the EPC (effective protection coefficient). These ratios are important summary statements that capture the extent of government policy interventions in the markets for tradable commodities. Type in the following statements beginning below the DISPLAY statement of the social prices report generator.

```
$TITLE      PROTECTION COEFFICIENTS CALCULATED FROM MAYALAND DATA

   SET          COEFF   /NOPC, NIPC, EPC/
   PARAMETER    POLICY  SUMMARY OF CROPWISE PROTECTION COEFFICIENTS;

   POLICY("NOPC", J)  =   ACTREP("GROSSREV", J)/ACTREPS("GROSSREV", J);
   POLICY("NIPC", J)  =   ACTREP("INPUTCO", J)/ACTREPS("INPUTCO", J);
   POLICY("EPC", J)   =   ACTREP("NETREV", J)/ACTREPS("NETREV", J);

   DISPLAY POLICY;
```

The protection coefficients generated by the equations shown above provide ample evidence of the Mayaland government's intervention in agricultural policy. Nominal protection coefficients for

corn and peanuts show a subsidy while those for beans and sorghum show that a tax is being levied on farmers.

Input prices reflect subsidizes for all crops. Identifying the culprit requires reference to the more detailed I-O table and to the prices table. From these two data sets it is evident that the major source of the subsidies is fertilizer.

Corn receives the largest per hectare subsidy when both outputs and inputs are considered. Its EPC is substantially greater than its initial NPC for output and underscores the fact that both inputs and outputs need to be considered before the true extent of protection can be determined. In this case the Mayaland government presumably has a strong interest in increasing food security and hence is providing generous incentives for farmers to produce corn.

---- 204 PARAMETER POLICY SUMMARY OF CROPWISE PROTECTION COEFFICIENTS

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS
NOPC	1.200	1.200	1.200	1.200	1.200	0.500
NIPC	0.549	0.549	0.549	0.549	0.549	0.536
EPC	-1.016	4.867	3.404	3.058	4.867	0.473

+	SORGHUM	PEANUTS
NOPC	0.812	1.400
NIPC	0.550	0.696
EPC	0.962	2.409

CHAPTER 6: FACTOR MARKETS IN THE MAYALAND MODEL

Budgeting (PAM) models differ in orientation from the l.p. models described above principally by the way in which factor markets are modeled. In the partial equilibrium approach, only a single factor or bundle of factors is assumed to be uniquely fixed to agriculture. The opportunity costs of other factors, e.g., capital and labor, are assumed to be determined in national markets that include other segments of the economy as well.

The treatment in the Mayaland models thus far is the opposite extreme, namely, there are no markets for the factors at all. As Hazell and Norton note (pp. 45-46), adding markets for factors to l.p. models is straightforward. Including the possibility of hiring in labor, for example, requires only (1) some additional variables that "supply" labor to the right hand side of the factor using ("demand") rows, and (2) a negative term in the objective function that penalizes the model for hiring outside labor. The units will be those already specified in the model. The unit value subtracted in the objective function refers to pesos per man month.

To create the new model, follow earlier methods in which a copy of the previous model was used as the basis for the next step. In GAMS, debugging goes much faster this way and the amount of typing is reduced. To create the necessary copy of the model, at the DOS prompt, type following DOS command: COPY MYPRIVT4 MYMARKT1. Use MYMARKT1 to complete the following exercise. A full version of the labor market extension to the section of the model based on private prices has been appended. However, in the interest of learning GAMS, it would be wise to try to follow, as much as possible, the steps as outlined and to use the model that has been provided as confirmation.

ADDING A PRIVATE LABOR MARKET

Hiring In Labor

Adding a labor market to the private prices section of the MYMARKT1 model that permits farmers to hire in additional annual labor requires the following steps:

Step 1

Define a new variable called "HIREIN" and add it to the list of variables. Note that it must also be added to the list of positive variables. It must be separated from the other variable names by a comma, e.g., POSITIVE VARIABLES CROPS, HIREIN;

Step 2

Define a new scalar called "WAGEIN" and add it to the list of scalars. Hazell and Norton indicate that wage rates in Mayaland are 50 pesos per month. At this rate, the annual wage would be 600 pesos.

WAGEIN WAGES OF HIRED LABOR /600/

Step 3

Add the labor supplied by the labor hiring activity to the labor supply row, i.e., rewrite the labor equation as follows:

CONSTLA(S)..SUM(J, LABOR(S, J)*CROPS(J)) =L= AMTLAB + HIREIN;

Step 4

Compute a labor cost term to be added to the objective function. The term can be computed in the same way as the INCOST term. First, a variable called LABCOST under the VARIABLES section. Second, the equation LABORC must be defined in the EQUATIONS section. Finally, a new equation, shown below, must be written that can be included in the objective function.

LABORC.. LABCOST =E= WAGEIN * HIREIN

Step 5

Add the labor cost term to the objective function. The objective function will now read:

OBJFN.. Z =E= REVENUE-COST-LABCOST

Hiring Labor Out

Where possibilities exist for hiring in, possibilities for farmers with small holdings to hire out their excess labor will also surely exist. This aspect of the labor market can be modeled by reversing the signs on the steps followed above:

Step 1

Define a new variable called "HIREOUT" and add it to the list of variables. Note that it too must be added to the list of variables that are required to take on positive values.

Step 2

Define a new scalar called "WAGEOUT" and add it to the list of scalars. Assume that transaction costs involved in searching for a job, as well as its impact on social status, effectively discount the wage received to, say, 40 pesos per month. This would mean 480 pesos for the annual wage. The entry in the SCALAR section would then be:

WAGEOUT WAGES FOR HIRING OUT /480/

Step 3

Subtract the labor demanded by labor hiring out activity from the labor availability row. This means rewriting the labor equation as follows:

```
CONSTLA(S).. SUM(J, LABOR(S, J)*CROPS(J)) =L= AMTLABOR+ HIREIN-HIREOUT;
```

Step 4

Compute a labor revenue term to be added to the objective function. The term can be computed in the same way as the LABCOST term. First, it must be defined as a variable called LABREV under the VARIABLES section. Second, the equation LABORR must be defined in the EQUATIONS section. Finally, a new equation, shown below, must be written to compute a term that can be included in the objective function.

```
LABORR..    LABREV  =E=  WAGEOUT * HIREOUT
```

Step 5

Add the computed labor revenue term to the objective function. The objective function will now read:

```
OBJFN..          Z =E=  REVENUE-COST-LABCOST + LABREV
```

After the new model is running and the bugs from the SOLVE statement have been worked out, add statements to the report generator that report the labor market results. This requires the following additions:

(a) Add a set named HIRE with the elements LABORIN and LABOROUT

(b) Add a parameter called LABORH LABOR HIRING SUMMARY (If it is the last statement in the PARAMETER declaration, it must be followed by a semi-colon.)

(c) Add a series of statements that create the labor summary table:

```
LABORH ("LABORIN")     =    HIREIN.L;
LABORH ("LABOROUT")    =    HIREOUT.L;
```

(d) Add LABORH to the DISPLAY statement

COMPARISON OF MARKET RESULTS (PRIVATE PRICES)

The table below compares the results extracted from the output of the MYPRIVT4 and MYMARKT1 models reflecting the absence or presence of a private labor market. Both of these models contain the diminishing returns to corn weeding labor developed in Chapter 3.

Without a Labor Market (Private Prices)

```
---------------------------------------------------------------------------
REPORT ON MYPRIVT4 SOLUTION

----    141 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE
OBJECTIVE 7080.332

----    141 PARAMETER ACTREP        VARIABLES SUMMARY
              CORNNW      CORNL1      CORNL2      CORNL3    CORNMULE
GROSSREV    1350.000    2250.000    2475.000    2580.000    2250.000
INPUTCO      875.000     875.000     875.000     875.000     875.000
NETREV       475.000    1375.000    1600.000    1705.000    1375.000
LEVEL                      1.220
REDCOSTS     -77.198                -723.769   -1441.571         EPS

      +        BEANS     SORGHUM      PEANUTS
GROSSREV    2250.000    2015.000    6881.000
INPUTCO     1035.000     495.000    2015.000
NETREV      1215.000    1520.000    4866.000
LEVEL          0.059       1.879       0.509

----    141 PARAMETER CONREP          DOMESTIC RESOURCE USE SUMMARY
           LAND       LABOR       MULES
JAN                               4.212
FEB        0.059      0.016       4.212
MAR        0.059      0.021       4.212
APR        1.787      0.542       4.212
MAY        3.667      1.375       4.212
JUN        3.608      1.375       4.212
JUL        3.608      1.375       4.212
AUG        2.388      1.219       4.212
SEP                   0.220       4.212
OCT                   0.439       4.212
NOV                   0.685       4.212
DEC                               4.212

----    141 PARAMETER CONMARG        SHADOW PRICES OF DOMESTIC RESOURCES
          LABOR
MAY    2430.000
JUN     312.672
JUL    1259.676
```

With a Labor Market (Private Prices)

```
REPORT ON MYMARKT1 SOLUTION

----    153 PARAMETER OBJFUN        OBJECTIVE FUNCTION VALUE

OBJECTIVE 8890.290

----    153 PARAMETER ACTREP        VARIABLES SUMMARY
              CORNNW      CORNL1      CORNL2      CORNL3    CORNMULE
GROSSREV    1350.000    2250.000    2475.000    2580.000    2250.000
INPUTCO      875.000     875.000     875.000     875.000     875.000
NETREV       475.000    1375.000    1600.000    1705.000    1375.000
LEVEL                                  1.151
REDCOSTS    -877.676     -90.070                  -7.394     -90.070

      +        BEANS      SORGHUM     PEANUTS
GROSSREV    2250.000    2015.000    6881.000
INPUTCO     1035.000     495.000    2015.000
NETREV      1215.000    1520.000    4866.000
LEVEL                      3.341       0.509
REDCOSTS     -57.451

----    153 PARAMETER CONREP        DOMESTIC RESOURCE USE SUMMARY
           LAND       LABOR       MULES
JAN                               5.763
FEB                               5.763
MAR                               5.763
APR       1.659       0.494       5.763
MAY       5.000       2.127       5.763
JUN       5.000       2.214       5.763
JUL       5.000       2.214       5.763
AUG       3.849       1.950       5.763
SEP                   0.207       5.763
OCT                   0.414       5.763
NOV                   1.036       5.763
DEC                               5.763

----    153 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES
           LAND       LABOR
MAY    1272.451
JUN                  374.648
JUL                  225.352
```

```
----    154 PARAMETER LABORH        LABOR HIRING SUMMARY

        LABORIN
JAN       0.839
FEB       0.839
MAR       0.839
APR       0.839
MAY       0.839
JUN       0.839
JUL       0.839
AUG       0.839
SEP       0.839
OCT       0.839
NOV       0.839
DEC       0.839
```

Labor was the only significant binding constraint in the without market case; it had a significant opportunity cost in May, June and July. After the addition of the labor market, its opportunity cost (shadow price) has been reduced considerably and now reflects the cost of hired labor. (Note that the 600 pesos representing the opportunity cost of hired labor are split between labor in June and labor in July.) The decline in labor scarcity results in a substantial increase in output, the emergence of land as a constraining factor of production, and a movement upward along the diminishing returns corn production function.

The figure for the monthly availability of annually hired labor, while capturing part of the "lumpiness" of assumption that labor will only work under a yearly contract, is still unsatisfactory in the sense that the LABOR HIRE decision variable should really be an integer. The present result is that .839 of a laborer could be hired annually; a mixed integer program of the sort discussed in Chapter 8 would have returned a 1.00 instead of .839 with the result that annual labor costs would have risen significantly. Question: Think about what making the labor hiring variable an integer would have done to monthly labor use? Would the higher annual labor costs increased or decreased labor use?

ALTERNATIVE ASSUMPTIONS ABOUT LABOR MARKETS

In the original Mayaland model, it was assumed that there was no market for labor. In MYMARKT1, this assumption was relaxed to some extent and it was assumed that labor could be hired annually. By implication, the skill level of hired labor was equal to the skills of the original family labor.

In agricultural sectors where there is a high degree of unemployment, or in situations where the model's specification distinguishes between different labor skills, it may be desirable to include a market for labor that can be hired in or hired out by the month. Changing MYMARKT1 to accommodate this interpretation of the existing market structure consists of (1) changing the wages

scalar to reflect pesos per month and (2) adding a seasonal subscript to variables, HIREIN and HIREOUT. The correct statements for the monthly labor hiring scalars are shown below.

WAGEIN WAGES OF LABOR HIRED IN (MONTHLY) /50/
WAGES OF LABOR HIRED OUT (MONTHLY) /40/

An example of the addition of the seasonal subscript is shown in the labor cost equation given below:

LABCOST =E=SUM(S, WAGEIN* HIREIN(S));

The same changes need to be made in other equations where the variables HIREIN and HIREOUT appear. Do not forget to change their values in the report generator as well.

The result of making labor a more divisible factor is to increase net revenues significantly. In part, the increase in revenues is generated by cost reductions that occur when labor is only hired in the month in which it is needed. In the present model, revenue is also generated by the off-farm employment of farmers during periods when they did not have remunerative employment on their own farms.

REPORT ON MYSOCIAL SOLUTION (MONTHLY LABOR HIRING ACTIVITIES)
---- 154 PARAMETER OBJFUN OBJECTIVE FUNCTION VALUE

OBJECTIVE 10085.289

---- 154 PARAMETER ACTREP VARIABLES SUMMARY

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE
GROSSREV	1350.000	2250.000	2475.000	2580.000	2250.000
INPUTCO	875.000	875.000	875.000	875.000	875.000
NETREV	475.000	1375.000	1600.000	1705.000	1375.000
LEVEL				4.491	
RCOSTS	-1122.600	-261.600	-70.600		-261.600

+	BEANS	SORGHUM	PEANUTS
GROSSREV	2250.000	2015.000	6881.000
INPUTCO	1035.000	495.000	2015.000
NETREV	1215.000	1520.000	4866.000
LEVEL			0.509

---- 154 PARAMETER CONREP DOMESTIC RESOURCE USE SUMMARY

	LAND	LABOR	MULES
JAN			5.229
FEB			5.229
MAR			5.229

```
APR        5.000        1.396        5.229
MAY        5.000        4.944        5.229
JUN        5.000        4.898        5.229
JUL        5.000        1.179        5.229
AUG        0.509        0.280        5.229
SEP                     1.078        5.229
OCT                     1.797        5.229
NOV                     0.234        5.229
DEC                                  5.229

----    154 PARAMETER CONMARG       SHADOW PRICES OF DOMESTIC RESOURCES
           LAND        LABOR
JAN                   40.000
FEB                   40.000
MAR                   40.000
APR      111.900      50.000
MAY     1027.900      50.000
JUN      408.500      50.000
JUL                   40.000
AUG                   40.000
SEP                   40.000
OCT                   50.000
NOV                   40.000
DEC                   40.000

----    154 PARAMETER LABORH        LABOR HIRING SUMMARY
        LABORIN     LABOROUT

JAN                    1.375     (All family labor hired out)
FEB                    1.375     (All family labor hired out)
MAR                    1.375     (All family labor hired out)
APR        0.021                 (Family labor used, additional labor hired in)
MAY        3.569                 (Family labor used, additional labor hired in)
JUN        3.523                 (Family labor used, additional labor hired in)
JUL                    0.196     (Some family labor used, remainder hired out)
AUG                    1.095     (Some family labor used, remainder hired out)
SEP                    0.297     (Some family labor used, remainder hired out)
OCT        0.422                 (Family labor used, additional labor hired in)
NOV                    1.141     (Some family labor used, remainder hired out)
DEC                    1.375     (Some family labor used, remainder hired out)
```

As the comparison with the MYPRIVT4 "with labor market" solution given previously indicates, the shadow prices of labor differ significantly depending on the assumptions made about the divisibility of labor supplies. In both cases, the shadow prices reflect the market prices of labor. However, in the annual labor models, the annual wage of 600 pesos is inputed to two months, June and July. In the monthly market, the monthly wage is inputed in each month depending upon whether labor is being hired in or hired out. The bottom line: simply adding a factor market is not

the end of the story. Care must be taken to get the institutional characteristics of the market right. This often means substantial disaggregation of tasks. For example, in many agricultural situations, family members may perform management functions, permanent hired labor may be employed to operate machines, and casual labor hired by the month or the day will be used for picking and harvesting.

ADDING A LABOR MARKET AT SOCIAL PRICES

As it stands, MYMARKT1, derived from MYPRIVT4, has no parallel social model. The focus in this exercise was to see how a market might be added and how it affects the choice of technique when diminishing returns to the factor are present.

Extending the social prices equations shown in the MYPOLICY model to a model called MYMARKT2 is straightforward. It can be done in one of two ways: (1) add the extensions that simulate a labor market as developed in MYMARKT1 to the MYPOLICY model or (2) add the social model contained in to MYMARKT1. The latter is probably the simplest and has been reported in the model described below.

As the social prices section of MYPOLICY shows, adding a social prices section is largely a matter of adding an "S" to the names of scalars, parameters and equations that are affected by the computation of social revenues. (The model's SOLVE statement must also be repeated.) For example, the scalars become WAGEINS and WAGEOUTS. The new definitions for computing labor cost and labor revenue become LABORCS and LABORREVS. (The latter must, of course, be added to the definition statement that indicates the equations that are to be included in the social prices model.) The social prices solution is then generated by a second SOLVE statement.

Similar changes must be made in the report generator. The new SET element becomes HIRES and the new table (parameter) definition becomes LABORHS. Variables remain the same because the definitions of activities are not changed from the private prices model.

The values that should be given to the social prices data set are the subject of lengthy discussion in Monke and Pearson (Chapter 7, "The Social Valuation of Factors"). For the purpose of the comparisons shown below, 50 pesos per month (600 per year) are used for WAGEINS and 40 (480 per year) for WAGEOUTS. The implication of using these values is that the market for annual labor is functioning reasonably well and therefore private wages can be taken as a measure of labor's social marginal product. Alternative assumptions can easily be incorporate.

A DETAILED LABOR MARKET MODEL

The partial model shown below contains the details of the extensions required to simulate a labor market.

```
SCALARS
```

```
AMTLAND   AMOUNT OF LAND AVAILABLE (HECTARES)      /5/
AMTLAB    AMOUNT OF LABOR AVAILABLE (BY MONTH)     /1.375/
AMTMULE   MULE POWER AVAILABLE (MONTHS)            /10/
MARKET    MARKET CONSTRAINT ON PEANUTS(KGS)        /500/
WAGEIN    WAGES OF LABOR HIRED IN (MONTHLY)        /50/
WAGEOUT   WAGES OF LABOR HIRED OUT (MONTHLY)       /40/
```

Note that wages have been changed from an annual value to a monthly wage rate.

```
VARIABLES
            REVENUE    GROSS REVENUE FROM CROP ACTIVITIES
            COST       TRADABLE INPUT COSTS
            LABCOST    COST OF HIRING IN LABOR
            LABREV     REVENUE FROM HIRING OUT
            CROPS      LEVELS OF THE CROP ACTIVITIES
            HIREIN     LABOR HIRED IN
            HIREOUT    LABOR HIRED OUT
            Z          TOTAL VALUE ADDED FROM CROP ACTIVITIES
                      POSITIVE VARIABLES CROPS, HIREIN, HIREOUT

EQUATIONS

  REV            COMPUTATION OF GROSS REVENUES
  INCOST         COMPUTATION OF TRADABLE INPUT COSTS
  LABORC         COMPUTATION OF LABOR COST
  LABORR         COMPUTATION OF LABOR REVENUE
  CONSTL(S)      LAND CONSTRAINT
  CONSTLA(S)     LABOR CONSTRAINT
  CONSTMUL       MULE CONSTRAINT
  MARKT          MARKET CONSTRAINT ON PEANUTS
  OBJFN          OBJECTIVE FUNCTION;
```

Seasonal subscripts, i.e., S, have been added to the labor market computations in the equations cited below.

```
  REV..       REVENUE -E- SUM(J,YIELDS(J)*PROUTP(J)*CROPS(J));
  INCOST..    COST    -E- SUM((I, J), IN(I,J)*PRINP(I)*CROPS(J));
  LABORC..    LABCOST -E- SUM(S, WAGEIN*HIREIN(S));
  LABORR..    LABREV  -E- SUM(S, WAGEOUT*HIREOUT(S));
  CONSTL(S)..     SUM(J, LAND(S,J)*CROPS(J)) -L-AMTLAND;
  CONSTLA(S)..    SUM(J, LABOR(S,J)*CROPS(J)) -L-AMTLAB+HIREIN(S)-HIREOUT(S);
  CONSTMUL..      SUM(J, MULES(J)*CROPS(J)) -L-AMTMULE;
  MARKT..         SUM(J, MP(J)* CROPS(J)) -L-MARKET;
  OBJFN..         Z -E- REVENUE-COST-LABCOST+ LABREV;

MODEL MYMARKT2/ALL/;
SOLVE MYMARKT2 USING LP MAXIMIZING Z;
```

```
$TITLE                  REPORT ON MYMARKT2 SOLUTION

     SETS      AREP      /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
               CREP      /LAND, LABOR, MULES/
               OBJ       /OBJECTIVE/
               HIRE      /LABORIN, LABOROUT/

     PARAMETERS     ACTREP    VARIABLES SUMMARY
                    CONREP    DOMESTIC RESOURCE USE SUMMARY
                    CONMARG   SHADOW PRICES OF DOMESTIC RESOURCES
                    OBJFUN    OBJECTIVE FUNCTION VALUE
                    LABORH    LABOR HIRING SUMMARY;

     ACTREP("GROSSREV", J)   =   YIELDS(J)*PROUTP(J);
     ACTREP("INPUTCO", J)    =  SUM(I, IN(I, J)*PRINP(I));
     ACTREP("NETREV", J)     =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
     ACTREP("LEVEL",J)       =  CROPS.L(J);
     ACTREP("REDCOSTS",J)    =   CROPS.M(J);

     OBJFUN("OBJECTIVE")        =     Z.L;

     CONREP(S,"LAND")           =     SUM(J, CROPS.L(J)*LAND(S,J));
     CONREP(S,"LABOR")          =     SUM(J, CROPS.L(J)*LABOR(S,J));
     CONREP(S,"MULES")          =     SUM(J, CROPS.L(J)*MULES(J));

     CONMARG(S,"LAND")          =     CONSTL.M(S);
     CONMARG(S,"LABOR")         =     CONSTLA.M(S);
     CONMARG(S,"MULES")         =     CONSTMUL.M;

     LABORH(S,"LABORIN")          =     HIREIN.L(S);
     LABORH(S,"LABOROUT")         =     HIREOUT.L(S);

  DISPLAY OBJFUN, ACTREP, CONREP, CONMARG, LABORH;

*---------------------------------------------------------------------
$TITLE          OPTIMAL SOLUTION WITH SOCIAL PRICES

SCALARS         WAGEINS     SOCIAL WAGES OF HIRED IN LABOR      /50/
                WAGEOUTS    SOCIAL WAGES OF HIRED OUT LABOR     /40/

PARAMETERS

  SOOUTP(J)  PRICES OF CROP OUTPUT (PESOS PER KG)
             /CORNNW 2.5, CORNL1 2.5, CORNL2 2.5, CORNL3 2.5, CORNMULE 2.5,
              BEANS  12, SORGHUM 3.2, PEANUTS 5/

  SOINP(I)   PRICES OF INPUTS (PESOS PER KG)
           /FERT 28, PEST 450,CORNSEED 4, BEANSEED 14, SORGSEED 4, PEASEED 7/
```

```
EQUATIONS
            REVSO          REVENUE COMPUTATION AT SOCIAL PRICES
            INCOSTSO       COST COMPUTATION AT SOCIAL PRICES
            LABORCS         LABOR COST COMPUTATION
            LABORRS         LABOR REVENUE COMPUTATION;

         REVSO..        REVENUE -E- SUM(J, YIELDS(J)*SOOUTP(J)*CROPS(J));
         INCOSTSO..     COST    -E- SUM((I,J), IN(I,J)*SOINP(I)*CROPS(J));
         LABORCS..      LABCOST -E- SUM(S, WAGEINS*HIREIN(S));
         LABORRS..      LABREV  -E- SUM(S, WAGEOUTS*HIREOUT(S));

MODEL MYMARKT3 /REVSO, INCOSTSO, LABORCS, LABORR, CONSTL, CONSTLA,
                CONSTMUL, MARKT, OBJFN/;
SOLVE MYMARKT3 USING LP MAXIMIZING Z;

$TITLE                  REPORT ON MYSOCIAL SOLUTION

     SETS      AREPS     /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
               CREPS     /LAND, LABOR, MULES/
               OBJS      /OBJECTIVE/
               HIRES     /LABORIN, LABOROUT/

     PARAMETERS     ACTREPS    VARIABLES SUMMARY
                    CONREPS    DOMESTIC RESOURCE USE SUMMARY
                    CONMARGS   SHADOW PRICES OF DOMESTIC RESOURCES
                    OBJFUNS    OBJECTIVE FUNCTION VALUE
                    LABORHS    HIRED LABOR SUMMARY;

   ACTREPS("GROSSREV", J)   =   YIELDS(J)*SOOUTP(J);
   ACTREPS("INPUTCO", J)    =  SUM(I, IN(I, J)*SOINP(I));
   ACTREPS("NETREV", J)     =   ACTREPS ("GROSSREV", J)-ACTREPS("INPUTCO", J);
   ACTREPS("LEVEL",J)       =  CROPS.L(J);
   ACTREPS("REDCOSTS",J)    =   CROPS.M(J);

   OBJFUNS("OBJECTIVE")        =     Z.L;

   CONREPS(S,"LAND")           =     SUM(J, CROPS.L(J)*LAND(S,J));
   CONREPS(S,"LABOR")          =     SUM(J, CROPS.L(J)*LABOR(S,J));
   CONREPS(S,"MULES")          =     SUM(J, CROPS.L(J)*MULES(J));


   CONMARGS(S,"LAND")          =     CONSTL.M(S);
   CONMARGS(S,"LABOR")         =     CONSTLA.M(S);
   CONMARGS(S,"MULES")         =     CONSTMUL.M;

   LABORHS(S,"LABORIN")          =     HIREIN.L(S);
   LABORHS(S,"LABOROUT")         =     HIREOUT.L(S);

  DISPLAY OBJFUNS, ACTREPS, CONREPS, CONMARGS, LABORHS;
```

*----------

As expected from the earlier computation, the output from the MYMARKT2 model at social prices differes significantly from private prices version shown in the previous output panel. Beans become the dominant crop and even peanuts no longer have a comparative advantage.

REPORT ON MYMARKT2 SOLUTION AT SOCIAL PRICES

---- 219 PARAMETER OBJFUNS OBJECTIVE FUNCTION VALUE

OBJECTIVE 13144.750

---- 219 PARAMETER ACTREPS VARIABLES SUMMARY

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE
GROSSREV	1125.000	1875.000	2062.500	2150.000	1875.000
INPUTCO	1592.500	1592.500	1592.500	1592.500	1592.500
NETREV	-467.500	282.500	470.000	557.500	282.500
RECOSTS	-2419.800	-1704.800	-1548.300	-1491.800	-1704.800

+	BEANS	SORGHUM	PEANUTS
GROSSREV	4500.000	2480.000	4915.000
INPUTCO	1932.500	900.000	2895.000
NETREV	2567.500	1580.000	2020.000
LEVEL	5.000		

---- 219 PARAMETER CONREPS DOMESTIC RESOURCE USE SUMMARY

	LAND	LABOR	MULES
JAN			6.350
FEB	5.000	1.350	6.350
MAR	5.000	1.800	6.350
APR	5.000	2.500	6.350
MAY	5.000	2.500	6.350
JUN			6.350
JUL			6.350
AUG			6.350
SEP			6.350
OCT			6.350
NOV			6.350
DEC			6.350

---- 219 PARAMETER CONMARGS SHADOW PRICES OF DOMESTIC RESOURCES

	LAND	LABOR
JAN		40.000
FEB	581.500	40.000
MAR		50.000
APR	407.200	50.000
MAY	1500.000	50.000
JUN		40.000

JUL	40.000
AUG	40.000
SEP	40.000
OCT	40.000
NOV	40.000
DEC	40.000

---- 219 PARAMETER LABORHS HIRED LABOR SUMMARY

	LABORIN	LABOROUT
JAN		1.375
FEB		0.025
MAR	0.425	
APR	1.125	
MAY	1.125	
JUN		1.375
JUL		1.375
AUG		1.375
SEP		1.375
OCT		1.375
NOV		1.375
DEC		1.375

CHAPTER 7: COMPUTING PAMS'S AND DRC'S WITH GAMS

It is clear from the Monke-Pearson text that a major impetus to the development of the policy analysis matrix (PAM) approach was the need for tools that could be explained and grasp by policy makers with very little training in economics. Coefficients are derived from simple budgets, a procedure that is also relatively easy to explain and implement. However, as noted earlier, there are inherent difficulties with such an approach when large numbers of fixed factors are present. In such situations, the optimal combination of resources ordinarily requires the production of more than one crop.

Chapter 6 added markets for previously fixed factors such as labor to the model. Treating these factors as variable costs opens the way for more direct comparisons between PAM's created with budgeting tools and PAM's created by l.p. models. In the market versions of the l.p. model, capital and labor still have shadow prices, but their values are now determined by considerations outside the model. For example, the scalars WAGEINS and SORATE are determined by reference to observed, economy-wide data rather than being generated internally by the model.

The only remaining fixed factor is land. However, because its seasonal dimension has been included in the model, the role of land differs in an optimization model from its role in budgeting exercises. Complex cropping systems in which a variety of crops can be grown in different time periods may lead to binding land constraints in more than one month. The resulting optimal solution is then likely to contain several crops in which the farming system has a comparative advantage.

The policy analysis matrix does not prescribe how the coefficients in the PAM are to be calculated. In the exercises that follow, the optimizing capability of GAMS is combined with its report writer to develop a series of individual commodity PAMS that can be used for policy discussion in situations where an exposition of the linear programming framework is considered too technical for policy makers to follow. Several examples are then used to show the impact of factor market assumptions on PAM calculations.

CREATING PAMS ON GAMS: SEASONAL LABOR MARKETS

The first step in producing a PAM generator is to copy MYMARKT2 to MYPAM. MYPAM should be set up so that it (1) contains models that produce solutions at both private and social prices, and (2) has markets for labor and capital that can be given different interpretations.

In the exercises that follow, quantities for capital will be generated by the need for working capital to cover the cost of purchased inputs. The appropriate values can be generated for the private prices model with the use of the following GAMS assignment statement. (It will need to be repeated for the social prices model as well. Note that the use of different prices for inputs will lead to a different value for capital required even when the interest rate is the same... a potentially misleading impression about the functioning of the capital market.)

The assignment statement that computes the amount of working capital needed is given below:

```
PARAMETER       CAPPRI      WORKING CAPITAL TO COVER VARIABLE COSTS;
CAPPRI(J)   =   SUM(I, PRINP(I)*IN(I,J));
```

The second step is (1) to add equations to the model to describe the relationship between the capital requirements ("demands") of various crops and capital availability, and (2) to add activities to simulate a capital market that "supplies" capital. Scalars that simulate private and social interest rates must also be added and the objective function changed to include the cost of capital. Examples of the necessary changes for the private prices model are given below. The interest rate definition and capital requirement computation will have to be repeated for the social model:

```
SCALAR              PRRATE        PRIVATE INTEREST RATE      /.10/

VARIABLE            BORROW        CAPITAL BORROWING ACTIVITY
                    CAPCOST       COST OF BORROWING CAPITAL

EQUATIONS       CONSTCAP      CAPITAL CONSTRAINT
                CAPC          COMPUTATION OF CAPITAL COST;

        CONSTCAP..      SUM(J, CAPPRI(J)*CROPS(J)) =L= BORROW;
        CAPC..          CAPCOST =E= BORROW*PRRATE;

        OBJFN..       Z =E=  REVENUE-COST-LABCOST+LABREV-CAPCOST;
```

The third step in developing a GAMS PAM generator is (1) to add capital to the report generator and (2) to use the report writer to access the output from the optimal solution. It is in many ways similar to the calculations that have already been done in the policy chapter when various trade-related policy ratios were calculated. However, the generator shown below organizes the PAM in what has come to be a conventional format for PAM presentation. The statements refer to PAM's for CORNL3 and BEANS. Other crops can be obtained by (1) copying the initial CORNL3 statements, and (2) using the "find and replace" capabilities of the text editor to change the name of the crop.

The report generator below has been modified to incorporate the capital variable.

```
$TITLE                  REPORT ON MYMARKT SOLUTION

     SETS       AREP      /GROSSREV, INPUTCO, NETREV, LEVEL, REDCOSTS/
                CREP      /LAND, LABOR, CAPITAL /
                OBJ       /OBJECTIVE/
                HIRE      /LABORIN, LABOROUT, BORROWING/

     PARAMETERS     ACTREP     VARIABLES SUMMARY
                    CONREP     DOMESTIC RESOURCE USE SUMMARY
```

```
                CONMARG   SHADOW PRICES OF DOMESTIC RESOURCES
                OBJFUN    OBJECTIVE FUNCTION VALUE
                PFACTSUM   FACTOR MARKET SUMMARY;

    ACTREP("GROSSREV", J)   =   YIELDS(J)*PROUTP(J);
    ACTREP("INPUTCO", J)    =  SUM(I, IN(I, J)*PRINP(I));
    ACTREP("NETREV", J)     =   ACTREP ("GROSSREV", J)-ACTREP("INPUTCO", J);
    ACTREP("LEVEL",J)       =  CROPS.L(J);
    ACTREP("REDCOSTS",J)    =   CROPS.M(J);

    OBJFUN("OBJECTIVE")        =     Z.L;

    CONREP(S,"LAND")           =     SUM(J, CROPS.L(J)*LAND(S,J));
    CONREP(S,"LABOR")          =     SUM(J, CROPS.L(J)*LABOR(S,J));
    CONREP(S,"CAPITAL")        =     SUM(J, CROPS.L(J)*CAPPRI(J));

    CONMARG(S,"LAND")          =     CONSTL.M(S);
    CONMARG(S,"LABOR")         =     CONSTLA.M(S);
    CONMARG(S,"CAPITAL")       =     CONSTCAP.M;

    PFACTSUM(S,"LABORIN")         =      HIREIN.L(S);
    PFACTSUM(S,"LABOROUT")        =      HIREOUT.L(S);
    PFACTSUM(S,"BORROWING")          =   BORROW.L;

  DISPLAY OBJFUN, ACTREP, CONREP, CONMARG, PFACTSUM;
```

*----------

The code shown below is somewhat intimidating at first sight. However, as noted above, by using the "Copy" and "Find and Replace" facilities of the text editor, individual commodity PAMS can be created for all crops in a matter of a few minutes. The formulas themselves simply follow the definitions of the PAM given in Monke and Pearson.

```
$TITLE        COMMODITY PAMS

      SET   PAM  /PRIVATE, SOCIAL, PROFIT, DIFFER/

      PARAMETERS CL3PAM, BEANSPAM;


CL3PAM("PRIVATE", "GROSSREV") = ACTREP("GROSSREV", "CORNL3");
CL3PAM("PRIVATE", "INPUTCO")  = ACTREP("INPUTCO", "CORNL3");
CL3PAM("PRIVATE", "LAND")     = SUM(S, CONMARG(S, "LAND")*LAND(S,"CORNL3"));
CL3PAM("PRIVATE", "LABOR")    = SUM(S, CONMARG(S, "LABOR")*LABOR(S,"CORNL3"));
CL3PAM("PRIVATE", "CAPITAL") = CONSTCAP.M*CAPPRI("CORNL3");
CL3PAM("PRIVATE", "PROFIT")  =     CL3PAM("PRIVATE","GROSSREV")
                                  -CL3PAM("PRIVATE", "INPUTCO")
                                  -CL3PAM("PRIVATE", "LABOR")
                                  -CL3PAM("PRIVATE", "CAPITAL")
```

```
                                    -CL3PAM("PRIVATE", "LAND");


CL3PAM("SOCIAL", "GROSSREV") = ACTREPS("GROSSREV", "CORNL3");
CL3PAM("SOCIAL", "INPUTCO")  = ACTREPS("INPUTCO", "CORNL3");
CL3PAM("SOCIAL", "LAND")  = SUM(S, CONMARGS(S,"LAND")*LAND(S,"CORNL3"));
CL3PAM("SOCIAL", "LABOR") =  SUM(S, CONMARGS(S, "LABOR")* LABOR(S,"CORNL3"));
CL3PAM("SOCIAL", "CAPITAL")  = CONSTCAPS.M*CAPSOC("CORNL3");
CL3PAM("SOCIAL", "PROFIT")  =     CL3PAM("SOCIAL","GROSSREV")
                                  -CL3PAM("SOCIAL", "INPUTCO")
                                  -CL3PAM("SOCIAL", "LABOR")
                                  -CL3PAM("SOCIAL", "CAPITAL")
                                  -CL3PAM("SOCIAL", "LAND");


 CL3PAM("DIFFER", "GROSSREV") =   CL3PAM("PRIVATE", "GROSSREV")
                                   -CL3PAM("SOCIAL", "GROSSREV");

 CL3PAM("DIFFER", "INPUTCO")  =   CL3PAM("PRIVATE", "INPUTCO")
                                    -CL3PAM("SOCIAL", "INPUTCO");

 CL3PAM("DIFFER", "LABOR")    =   CL3PAM("PRIVATE", "LABOR")
                                    -CL3PAM("SOCIAL", "LABOR");

 CL3PAM("DIFFER", "CAPITAL")  =   CL3PAM("PRIVATE", "CAPITAL")
                                    -CL3PAM("SOCIAL", "CAPITAL");

 CL3PAM("DIFFER", "LAND")     =    CL3PAM("PRIVATE", "LAND")
                                   -CL3PAM("SOCIAL", "LAND");

 CL3PAM("DIFFER", "PROFIT")  =    CL3PAM("PRIVATE", "PROFIT")
                                    -CL3PAM("SOCIAL", "PROFIT");


BEANSPAM("PRIVATE", "GROSSREV") = ACTREP("GROSSREV", "BEANS");
BEANSPAM("PRIVATE", "INPUTCO")  = ACTREP("INPUTCO", "BEANS");
BEANSPAM("PRIVATE", "LAND")     = SUM(S, CONMARG(S, "LAND")*LAND(S,"BEANS"));
BEANSPAM("PRIVATE", "LABOR")    = SUM(S, CONMARG(S,"LABOR")*LABOR(S,"BEANS"));
BEANSPAM("PRIVATE", "CAPITAL") =  CONSTCAP.M*CAPPRI("BEANS");
BEANSPAM("PRIVATE", "PROFIT")  =    BEANSPAM("PRIVATE","GROSSREV")
                                   -BEANSPAM("PRIVATE", "INPUTCO")
                                   -BEANSPAM("PRIVATE", "LABOR")
                                   -BEANSPAM("PRIVATE", "CAPITAL")
                                   -BEANSPAM("PRIVATE", "LAND");


 BEANSPAM("SOCIAL", "GROSSREV") =   ACTREPS("GROSSREV", "BEANS");
 BEANSPAM("SOCIAL", "INPUTCO")  =   ACTREPS("INPUTCO", "BEANS");
```

```
BEANSPAM("SOCIAL", "LAND")    =    SUM(S,CONMARGS(S,"LAND")*LAND(S,"BEANS"));
BEANSPAM("SOCIAL", "LABOR") = SUM(S,CONMARGS(S,"LABOR")*LABOR(S,"BEANS"));
BEANSPAM("SOCIAL", "CAPITAL") =   CONSTCAPS.M*CAPSOC("BEANS");
BEANSPAM("SOCIAL", "PROFIT")  =      BEANSPAM("SOCIAL","GROSSREV")
                                    -BEANSPAM("SOCIAL", "INPUTCO")
                                    -BEANSPAM("SOCIAL", "LABOR")
                                    -BEANSPAM("SOCIAL", "CAPITAL")
                                    -BEANSPAM("SOCIAL", "LAND");

BEANSPAM("DIFFER", "GROSSREV") =   BEANSPAM("PRIVATE", "GROSSREV")
                                  -BEANSPAM("SOCIAL", "GROSSREV");

BEANSPAM("DIFFER", "INPUTCO")  =   BEANSPAM("PRIVATE", "INPUTCO")
                                   -BEANSPAM("SOCIAL", "INPUTCO");

BEANSPAM("DIFFER", "LABOR")    =   BEANSPAM("PRIVATE", "LABOR")
                                   -BEANSPAM("SOCIAL", "LABOR");

BEANSPAM("DIFFER", "CAPITAL")  =   BEANSPAM("PRIVATE", "CAPITAL")
                                   -BEANSPAM("SOCIAL", "CAPITAL");

BEANSPAM("DIFFER", "LAND")      =   BEANSPAM("PRIVATE", "LAND")
                                  -BEANSPAM("SOCIAL", "LAND");

BEANSPAM("DIFFER", "PROFIT")  =    BEANSPAM("PRIVATE", "PROFIT")
                                   -BEANSPAM("SOCIAL", "PROFIT");

$TITLE   .       PAMS FOR INDIVIDUAL COMMODITIES
DISPLAY CL3PAM, BEANSPAM;
```

Individual Commodity PAMS: The Results

The table below shows the results of the PAM generator shown above under the assumption that farmers have access, without limit, to seasonal (monthly) labor markets and capital markets where capital is modeled with a single constraint.

Several points about these two commodities are immediately evident.

(1) The individual crop protection ratios computed in the policy chapter and repeated below are verified. For example, in the case of CORNL3, the positive difference between the gross revenue of corn shows that farmers have received policy incentives to grow CORNL3, i.e., the NPC is positive. Moreover, while positive differences in gross revenues indicate a subsidy, subsidies in input costs are signaled by negative differences. When negative input cost differences are subtracted from positive gross revenues, the results are increases in the subsidy to value added--as indicated by a large EPC.

Private profits for corn are zero. This is the PAM equivalent of the l.p. result that the "reduced costs" are zero. (There would be no penalty if a unit of corn was forced into the optimal basis.) This result will be obtained for any commodity that is in the l.p. model's optimal solution. The entire value added (GROSSREV - INPUTCO) has been exhausted by the "variable" costs of domestic LABOR and CAPITAL and the imputed value of the fixed factor, LAND. (Notice that in the zero profit case, the value of land has been determined by the crop shown to have a comparative advantage over other crops, not the next best alternative.)

The results of the BEANSPAM are somewhat different. The negative number for GROSSREV indicates that farmers growing beans are being taxed, i.e., that private output revenues are substantially below world market prices. However, like corn, bean farmers are the beneficiaries of subsidized inputs. Indeed, they receive a greater per acre subsidy on bean inputs than they do on corn inputs.

At private prices, beans show a negative profit and are not in the optimal solution. At social prices, however, the improvement of relative bean prices has been such that they have replaced corn in the optimal solution and show zero social profits, i.e., they have a DRC of 1.00.

(2) The interpretation of the PAM's generated by the programming model is, in many ways, the same as if they had been computed from budgets. One obvious difference arises in the case of capital where a difference between private and social costs arises because the amount of working capital changes as the price of inputs change. That is, because of the subsidies on inputs, less capital is required to finance the various enterprises and, even where the costs of capital are assumed to be the same under private and social prices, the PAM gives the impression that policy interventions or market imperfections exist.

What is more significant as far as interpretation goes, however, is the difference between private and social land costs. That amount of land required to produce one hectare remains, of course, the same. But because of the model's response to the change in relative prices that has accompanied the movement from private to social prices, the shadow prices for land have also changed. The difference between private and social land costs do not, therefore, reflect imperfections in the land market but merely the response of that market to changes in the prices of inputs and outputs.

The labor market continues to reflect the assumptions of budgeting solutions. If there is no difference between private and social wages, there will be no difference between private and social labor costs. In the presence of a monthly labor market, the fact that cropping patterns change has no effect on the shadow price of labor or on the amount of labor required to grow one hectare of the crop. (In a subsequent example where the labor market is modeled differently, and where more than one crop determines the shadow price of labor, it will become apparent that differences between the two estimates may emerge as a result of the adjustments that are taking place in the model as comparative advantage is determined under two sets of relative prices.)

```
----     627 PARAMETER CL3PAM
           GROSSREV     INPUTCO        LAND       LABOR     CAPITAL      PROFIT

PRIVATE    2580.000     875.000    1456.500     161.000      87.500       0.000
SOCIAL     2150.000    1592.500    2292.750     161.000     159.250   -2055.500
DIFFER      430.000    -717.500    -836.250       0.000     -71.750    2055.500

----     627 PARAMETER BEANSPAM
           GROSSREV     INPUTCO        LAND       LABOR     CAPITAL      PROFIT

PRIVATE    2250.000    1035.000    1456.500      81.500     103.500    -426.500
SOCIAL     4500.000    1932.500    2292.750      81.500     193.250       0.000
DIFFER    -2250.000    -897.500    -836.250       0.000     -89.750    -426.500
```

Summary Trade Coefficients

The table below shows the various trade coefficients computed from the individual commodity PAMs. Most have been presented previously but, with the LAND marginals (shadow prices) from the optimization results available, it is now also possible to compute the private profit coefficients (PPC) and domestic resource cost (DRC) coefficients for each enterprise. (PPC is the ratio of domestic resources valued at private prices to valued-added at private prices; DRC is the ratio of domestic resources valued at social prices to value-added at social prices.)

As expected, all coefficients for commodities not in the optimal solution are greater than one indicating that the cost of resources (land, labor and capital), when valued at their private or social shadow prices, exceed value added when measured at its opportunity cost.

(The unfavorable PPC's and DRC's of low yielding corn activities show how important yields are in the determining comparative advantage.)

```
----     627 PARAMETER POLICY      SUMMARY OF CROPWISE PROTECTION COEFFICIENTS

           CORNNW       CORNL1       CORNL2       CORNL3     CORNMULE       BEANS

NOPC        1.200        1.200        1.200        1.200        1.200        0.500
NIPC        0.549        0.549        0.549        0.549        0.549        0.536
EPC        -1.016        4.867        3.404        3.058        4.867        0.473
PPC         3.358        1.189        1.048        1.000        1.169        1.344
DRC        -5.367        8.983        5.474        4.676        8.983        1.000
```

+	SORGHUM	PEANUTS
NOPC	0.812	1.400
NIPC	0.550	0.696
EPC	0.962	2.409
PPC	1.000	0.368
DRC	1.569	1.344

CREATING PAMS WITH GAMS: ANNUAL LABOR MARKETS

Because of the assumption in the previous exercise that seasonal labor and capital markets existed, the impact of the shadow prices of labor on the optimal enterprise combination was muted. As a result, only a single commodity, determined by the shadow price of the factor for which there was not market (land) appeared in the optimal private and social solutions. It was the determining factor in comparative advantage.

As noted previously, somewhat different results would have been obtained using a budgeting approach because budgets do not allow for changes in enterprise combinations and factor shadow prices as a result of changes in relative output prices. Aside from this "supply response" factor that would be a part of any policy reform that moved from private prices to social prices, the computations would have been similar.

However, a slightly different assumption about labor markets, namely the assumption that labor could only be hired annually, produces rather different results. Changing the model involves a few simple steps:

(1) Change the wage scalars from the cost of hiring an individual for one month to the cost of hiring one man month annually.

(2) Remove the seasonal ("S") subscript's from the HIREIN and HIREOUT variables.

(3) Change the first stage of the report generator to reflect the change in the seasonal dimension of the variables.

(4) Change the PAM generator so that the labor cost line in the table no longer sums over the seasons but simply multiples the annual wage times the number of man months hired on a fixed annual contract.

The PAM's shown below for CORNL3, BEANS and SORGHUM were computed under the assumption that the labor market contains "imperfections" that limit hiring to annual labor. (Note: the effective monthly wage rate remained the same; the change in assumptions has to do with the way in which labor can be hired.)

```
----    627 PARAMETER CL3PAM

           GROSSREV      INPUTCO         LAND        LABOR      CAPITAL       PROFIT

PRIVATE    2580.000      875.000     1216.658      400.842       87.500        0.000
SOCIAL     2150.000     1592.500     1514.500      162.000      159.250    -1278.000
DIFFER      430.000     -717.500     -297.842      238.840      -71.750     1278.000

----    627 PARAMETER BEANSPAM
             GROSSREV      INPUTCO         LAND        LABOR      CAPITAL       PROFIT

PRIVATE    2250.000     1035.000     1216.658                   103.500     -105.158
SOCIAL     4500.000     1932.500     2074.250      300.000      193.250        0.000
DIFFER    -2250.000     -897.500     -857.592     -300.000      -89.750     -105.158

----    627 PARAMETER SORGPAM
           GROSSREV      INPUTCO         LAND        LABOR      CAPITAL       PROFIT

PRIVATE    2015.000      495.000     1216.658      253.842       49.500        0.000
SOCIAL     2480.000      900.000     2074.250                    90.000     -584.250
DIFFER     -465.000     -405.000     -857.592      253.842      -40.500      584.250
```

A substantial number of PAM elements have, of course, remained the same. As noted previously, the interpretation of the columns showing distortions introduced through trade policies are unchanged. What has changed with the assumption of "imperfections" in the labor market introduced through hiring practices are the values for the shadow price of labor and, by the adding-up theorem, the shadow prices of other fixed factors. (The cost of capital changes because the change in the cropping pattern produces a new set of capital demands.) Values for the labor coefficients were computed by multiplying the seasonal shadow prices of labor times the monthly labor use. Annual hired labor is, however, a "lumpy" input; it is obviously possible in such cases for a crop to use labor in a month in which labor is generally in surplus. The resulting zero labor cost, when multiplied by the technical coefficient that describes labor use, still equal produces zero. This phenomenon accounts for the lack of labor costs in the private profit calculation for beans and the social profit calculation for sorghum.

The model hires 2.3 man months annually at private prices and 2.5 man months at social prices. An obvious extension of this exercise would be to model labor hiring as an integer variable, i.e., to insist that labor cannot be hired in fractions of a month. This further limits the flexibility of the labor market and introduces additional sources of divergence between private and social labor costs.

Summary Coefficients

The table below provides a summary of all of the PAM calculations. It reflects the requirements of equilibrium solutions in l.p. models. For example, at social prices, three crops

(beans, sorghum and peanuts) display a DRC of 1 indicating that they are all in the optimal solution. The interesting divergence from this rule occurs in the case of peanuts under private prices. It has a DRC of < 1 because the penalty imposed by the binding marketing constraint has not been included as a cost. (The marketing constraint is not binding in the social prices solution although peanuts are in the optimal basis.)

---- 627 PARAMETER POLICY SUMMARY OF CROPWISE PROTECTION COEFFICIENTS

	CORNNW	CORNL1	CORNL2	CORNL3	CORNMULE	BEANS
NOPC	1.200	1.200	1.200	1.200	1.200	0.500
NIPC	0.549	0.549	0.549	0.549	0.549	0.536
EPC	-1.016	4.867	3.404	3.058	4.867	0.473
PPC	2.908	1.076	1.004	1.000	1.076	1.087
DRC	-3.927	6.498	3.906	3.293	6.498	1.000

627 PARAMETER POLICY SUMMARY OF CROPWISE PROTECTION COEFFICIENTS

+	SORGHUM	PEANUTS
NOPC	0.812	1.400
NIPC	0.550	0.696
EPC	0.962	2.409
PPC	1.000	0.345
DRC	1.000	1.000

The impact of assuming that labor markets do not function perfectly would become even more pronounced if the MAYALAND model introduced in Chapter 2, in which labor was entirely fixed, was the basis of the PAM calculations.

In the usual budgeting approach, imperfections in capital and labor markets are handled by adjusting private prices to reflect social opportunity costs. But it is clear from the foregoing exercise that if various types of quantity restrictions also apply, they too will be reflected in the PAM's computed with optimization models.

AGRICULTURAL POLICY ANALYSIS PROJECT, PHASE II

Under contract to U.S.A.I.D., Bureau of Science and Technology, Office of Agriculture
Project Office: Hampden Square, 4800 Montgomery Lane, Suite 500, Bethesda, MD 20814
Telephone: (301) 913-0500 • Telex: 312636 • Fax: (301) 652-3839 • Fax: (301) 652-7791

[redacted]

AGRICULTURAL AND NATURAL RESOURCES POLICY ANALYSIS COURSE

Budgeting Approaches to Environmental Policy Analysis

Methods and Guidelines No. 401

Volume 5

Prepared for: Agricultural Policy Analysis Project, Phase II (APAP II)
A.I.D. Contract No. DAN-4084-Z-00-8043-00

Prime contractor: **Abt Associates, Inc.**, 55 Wheeler Street, Cambridge, MA 02138 • (617) 492-7100

Subcontractors:

Harvard Institute for International Development, Harvard University, One Eliot Street, Cambridge, MA 02138 • (617) 495-2164
Food Research Institute, Stanford University, Stanford, CA 94305-6084 • (415) 723-3941
North Carolina State University, Department of Economics and Business, Box 7645, Raleigh, NC 27695-7645 • (919) 737-7187
Abel, Daft & Earley, 1410 King Street, Alexandria, VA 22314 • (703) 739-9090
International Science and Technology Institute, 1129 20th Street, NW, Suite 800, Washington, D.C. 20036 •(202) 785-0831
International Food Policy Research Institute, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036 • (202) 862-5600

TABLE OF CONTENTS

CHAPTER 1: WHOLE-FARM PAMS 1
CREATING A WHOLE-FARM PAM 1
The Whole-Farm Input-Output Table 1
Private Prices and Private Budget Tables 1
Social Prices and Social Budgets 4
Computing a Whole-Farm PAM 4
INTERPRETING THE WHOLE-FARM PAM 6

CHAPTER 2: THE ECONOMICS OF SUSTAINABILITY: PRIVATE PRICES 8
COMPUTING A PRIVATE IRR FOR CONSERVATION MEASURES 9
Creating an "Investments" Table 9
Creating a Yield Degradation Table 10
Creating the IRR Calculation Table 12
SENSITIVITY ANALYSIS 15

CHAPTER 3: THE ECONOMICS OF SUSTAINABILITY: SOCIAL PRICES 16

CHAPTER 4: SUSTAINABILITY AND ALTERNATIVE FARMING SYSTEMS 18
ADDING A SECOND FARMING SYSTEM 18
Creating the I-O Table 18
Creating the Private and Social Prices Tables 18
Revising the Yield Degradation Table 20
Revising the IRR Tables 20
Expanding the Analysis Table 22

ANALYZING SUSTAINABILITY SCENARIOS 22

CHAPTER 5: COMBINING DEVELOPMENT AND SUSTAINABILITY 24
INCORPORATING YIELD ENHANCEMENT 24

CHAPTER 1: WHOLE-FARM PAMS

The study of natural resource economics requires greater flexibility in the description of farming systems than is found in a single commodity PAM analysis. In the case of soil erosion, for example, it is often the mix of crops that is grown--with an undue emphasis on high yielding, soil depleting crops--that is a major culprit of soil degradation. Similarly, in the case of fertilizers and pesticides, it is one particular crop that produces both on- and off-farm damage to the agricultural environment. Budgets that seek to incorporate cropping pattern effects must necessarily be based on a whole-farm model.

The model that follows is, of course, still not an optimization model. However, the ability to combine crops into acceptable rotations is easily accomplished and provides a useful tool in examining a variety of farming system problems.

CREATING A WHOLE-FARM PAM

The whole-farm PAM in this chapter consists of only two crops: rainfed paddy and rainfed maize. The number of crops can easily be expanded with the usual column insertions.

The Whole-Farm Input-Output Table

The input-output table for paddy and maize is given below. Each of the technical coefficients in the table, including outputs, is linked to the cell address containing the amount of land that is to be devoted to each crop. For example, the formula for the cell C5 (urea) is 167*C24. Output is also obtained by multiplying yield times area. (If the I-O table was obtained from Chapter 4 of the original PAM manual, use the Edit key (F2) to add the cell address of the land row.) Changes in output and income from changes in the cropping pattern or farm size can now be produced by simply typing in new values for the area under a particular crop.

Total resources used are given by summing over the quantities shown in columns C and D. The size of the farm is given by the summation of the land row. In the base case for Table 1.1, the farm contains two hectares.

Private Prices and Private Budget Tables

For convenience, the private prices and private budget tables are shown below. Create the tables by copying the I-O table along the diagonal. Enter the data as shown.

Table 1.1: Input-Output Table: Whole Farm PAM

	A	B	C	D	E
1	I-O	Input-Output Table	Rainfed	Rainfed	Total
2		Quantities	Paddy	Maize	
3					
4	Tradables:	Fertilizer (kg/ha)			
5		Urea	167	85	252
6		0-18-0	20		20
7		Chemicals (kg/ha)	2	.5	2.5
8		Seed (kg/ha)	115	40	155
9		Fuel (liter/ha)	0	0	0
10					
11	Factors:	Labor (man hours/ha)			
12		Seedbed preparation	65	50	115
13		Crops care	100	100	200
14		Harvesting	200	180	380
15		Threshing	5	0	5
16		Shelling		60	60
17		Drying	60	20	80
18					
19		Capital			
20		Working capital (P/ha)	3398	1630	5028
21		Tractor services (hr/ha)	140	120	260
22		Thresher (hr/ha)	40		40
23					
24		Land (ha)	1	1	2
25					
26		Output (total kgs)	2400	1270	
27		Yields (kgs/ha)	2400	1270	
28					

Table 1.2: Private Prices for a Whole Farm PAM

	G	H	I	J
30	P-Prices	Private Prices	Rainfed	Rainfed
31			Paddy	Maize
32				
33	Tradables:	Fertilizer (P/kg)		
34		Urea	3.8	3.8
35		0-18-0	2.3	2.3
36		Chemicals (P/kg)	120	120
37		Seed (P/kg)	6.0	4.8
38		Fuel (P/liter	6.7	6.7
39				
40	Factors:	Labor (P/man-hour)		
41		Seedbed preparation	7.5	7.5
42		Crop care	6.2	6.2
43		Harvesting	6.2	6.2
44		Threshing	7.0	7.0
45		Shelling	6.2	6.2
46		Drying	6.2	6.2
47				
48		Capital		
49		Working capital (%)	.14	.14
50		Tractor services (P/hr)	6.5	6.5
51		Thresher (P/hr)	12.5	12.5
52				
53		Land (ha)	1,500	1,500
54				
55		Output (kg/ha)	4.5	4.2
56				
57				

Table 1.3: Private Prices Budget for a Whole-Farm PAM

	L	M	N	O	P
82					
83		Total Revenue	10,800	5,334	16,134
84					
85		Total Costs (excluding Land)	6,251	4,190	10,441
86					
87		Profit (excluding land costs)	4,549	1,144	5,693
88					
89		Net Profit (including land costs)	3,049	(356)	2,693
90					

Social Prices and Social Budgets

Social prices and social budgets are identical to those created for single commodity PAMs except that they now contain an additional column that sums up the results for the entire farm. Totals shown for most items are not particularly noteworthy. However, the final results, in which the costs and expenditures for the whole farm are presented, is of concern to agricultural policy makers. It describes the overall cost and returns--and hence income--of a particular size farm.

Tables 1.4 and 1.5 show the social prices table and the portion of the social budgets table that is not a replica of the I-O table labels. As in the private budget case, the table should be created by first copying the I-O table along the diagonal. The I-O table already contains the additional "Total" column that will be needed to sum up the individual commodities into the whole-farm aggregates. The total revenue line is derived by the multiplication of the "Yield" cell in the I-O table times the output prices in the social prices table. The total cost (excluding land) row is obtained by summing over all costs except for the cost of land. Net profits (excluding land) are obtained by subtracting costs from revenues.

Computing a Whole-Farm PAM

The steps in creating a whole-farm PAM are identical to creating the PAM for a single commodity. The only difference is that the "Totals" column in the budget is used instead of the individual commodity columns.

Step 1:

Use the cell address of the total revenue row in the "Totals" column of the two budgets in order to obtain the PAM values for the cells A and E.

Table 1.4: Social Prices for a Whole Farm PAM

	R	S	T	U
92	S-Prices	Social Prices	Rainfed	Rainfed
93			Paddy	Maize
94				
95	Tradables:	Fertilizer (P/kg)		
96		Urea	4.8	4.8
97		0-18-0	3.3	3.3
98		Chemicals (P/kg)	105.0	105.0
99		Seed (P/kg)	6.0	4.8
100		Fuel (P/liter)	6.7	6.7
101				
102	Factors:	Labor (P/hr)		
103		Seedbed preparation	7.5	7.5
104		Crop care	6.2	6.2
105		Harvesting	6.2	6.2
106		Threshing	7.0	7.0
107		Shelling	6.2	6.2
108		Drying	6.2	6.2
109				
110		Capital		
111		Working capital (%)	.14	.14
112		Tractor services (P/hr)	6.5	6.5
113		Thresher (P/hr)	12.5	12.5
114				
115		Land (ha)	0.0	0.0
116				
117		Output (P/kg)	4.7	4.0
118				
119				

Step 2:

Use the @SUM function to sum over the tradable input costs in each budget to obtain the values for the PAM cells B and F. (Remember to use the Windows (unsynchronized) command to create a horizontal line on the screen so that you can see both the budgets and the PAM on the same screen.

Step 3:

Table 1.5: Social Prices Budget for a Whole-Farm PAM

	W	X	Y	Z	AA
144					
145		Total Revenue	11,280	5,080	16,360
146					
147		Total Costs (Excluding Land)	6,408	4,268	10,676
148					
149		Profit (Excluding land costs)	4,872	812	5,684
150					
151		Net Profit (Including land costs)	4,872	812	5,684
152					

Sum over the labor costs in both budgets to obtain the values for the PAM cells showing the private and social costs of labor.

Step 4:

Sum over the capital costs in both budgets to obtain the values for the PAM cells showing the private and social costs of capital.

Step 5:

Compute private and social profits by subtracting costs from revenues. Compute policy and market divergences by subtracting the bottom line of the PAM from the top line. Create a summary ratios table from the PAM results showing the NPC, EPC and DRC for the whole-farm budget.

INTERPRETING THE WHOLE-FARM PAM

The basic interpretation of the whole-farm PAM follows that of single commodity PAMs. Divergences in the output column, for example, refer to distortions created by under or over valued exchange rates and by direct taxes and subsidies. Since the social prices row has been obtained from the calculation of export or import parity prices, it is also possible that the divergences reflect the effects of nontraded goods and services such as transportation, marketing and processing. The whole-farm PAM is interesting because it provides an *aggregate* picture of the incidence of agricultural policy. Just as the effects of taxes on output may be off-set by subsidies on inputs, taxes on one crop may be off-set by subsidies in another.[1]

[1] In Egypt, for example, the government has historically taxed cotton; farmers refer to it as the "government's crop." At the same time, the government has placed import quotas on livestock products so that farmers who maintain livestock benefit from an implicit subsidy, i.e., they receive more than the world prices for their meat and milk. What the government apparently failed to appreciate was that fodder for animals competes directly with cotton for scarce

The same is true of inputs. The whole-farm PAM provides an aggregate picture of the extent to which the price of tradables used in the agricultural sector diverge from efficiency prices. It may be that some inputs are actually taxed in order to maintain inefficient domestic machinery and fertilizer industries. These taxes may be off-set by subsidies on the pesticides that farmers purchase. Cells B and F in the PAM sum up the total input divergences.

The domestic factor cost cells are now aggregates that sum across all crops. Note that only the opportunity costs of labor and capital are included. Land costs are irrelevant in the whole-farm PAM. The issue of comparative advantage *within agriculture* does not arise because the cropping pattern has been determined in the I-O table. (Analysts will surely want to consult the private and social budgets to look at relative profitability in determining the amount of land to be devoted to each crop.)

On the basis of these results, a cropping pattern can be determined that appears to yield a high return to agricultural resources. But with a whole-farm model, a variety of other determinants of the cropping pattern can also be taken into account. For example, some crops may be considerably riskier than others and hence farmers would deem it unwise to put all their eggs in one basket, even if the expected or average value of the crop is quite high. Rotational considerations reflecting a concern with sustainability can also be incorporated by choosing a crop mix that minimizes erosion or the possibility of soil borne diseases.

FarmPAM	Whole-Farm PAM				
	Outputs	Inputs	Labor	Capital	Profit
Private	16,134	2,186	5,362	2,894	5,693
Social	16,360	2,420	5,362	2,894	5,684
Divergence	(226)	(235)	0	0	9

land and water resources. The result has been a continued decline in cotton acreage over time.

CHAPTER 2: THE ECONOMICS OF SUSTAINABILITY: PRIVATE PRICES [2]

With a whole-farm model it place, it is now possible to use the results to investigate various aspects of the sustainability problem. Sustainability in this instance is defined as a continuation of present crop yields over a planning horizon of 20 years. Constant yields are shown as a horizontal line in Figure 2.1 and represents at least one definition of sustainability.

The "degradation" case is also shown. Initially, yields are assumed to decline slowly in presence of environmental degradation such as waterlogging, soil salinity, water erosion, and wind erosion. Midway in the planning horizon, a decline in productivity is assumed to occur rather rapidly followed by another distinct period in which yield declines occur gradually over time.

There is broad scientific evidence that environmental degradation in agriculture has the characteristics shown in Figure 1.1. In the case of soil erosion, for example, deep soils may go for years with substantial amounts of erosion and only modest declines in yields. In such cases, it is chiefly nutrients that are being lost and these can be replaced by applying fertilizer. Similarly, in irrigation systems, waterlogging and soil salinity may increase over decades with only a slight effect on yields. These effects an be overcome for a considerable period of time by improved water management and micro-drainage practices.

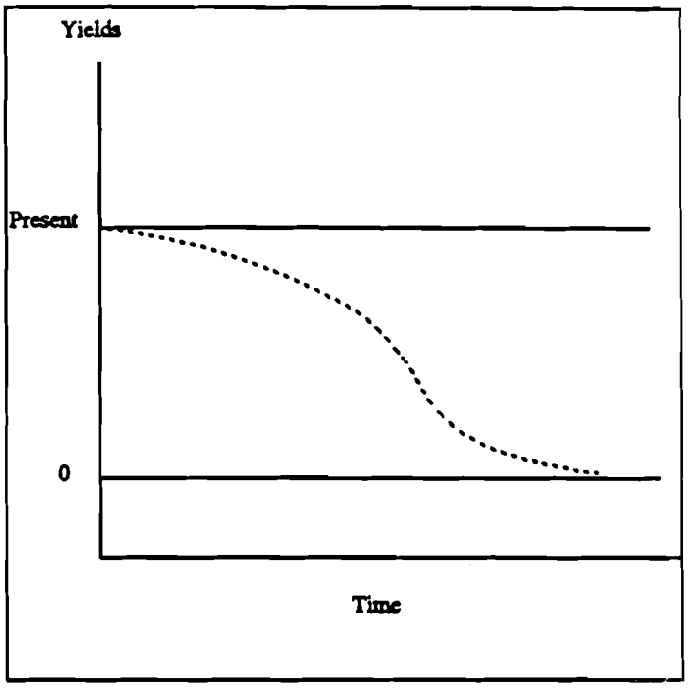


Figure 2.1: Yields Over Time

In both situations, however, at some point rapidly declining yields may set in. In the case of soils, it occurs when the favorable structure of the topsoil is replaced by underlying soil strata that have poor moisture and nutrient holding capacities. In the case of waterlogging, rapid yield declines occur once the water table reaches the root zone of plants.

The impact of different time profiles of yield degradation on returns to investment is significant. If conservation measures are implemented in the present in an effort to sustain yields at current levels, the rewards may, for a number of years, be minimal. However, the costs are to a

[2] The analysis in this and the following sections is based on several papers by Stefano Pagiola culminating in *The Cost Benefit Analysis of Soil Conservation*, Food Research Institute, August, 1991.

considerable extent incurred in the present. The combination of large costs in the early periods and significant benefits in the distant future to produce projects with very low internal rates of return on investment.

Figure 2.2 juxtaposes the yield degradation assumptions implicit in the typical "with" and "without" project appraisal with a stylized, linearly declining yield curve. In the conventional appraisal method, the decline in yields is assumed to occur immediately and uniformly throughout the project's lifetime.

It is easy to see that adjusting the without project case by the actual time stream of yield declines would yield a less favorable stream of benefits. Project returns are defined by the *difference* between the with and without cases and this difference would be less if actual yields were used in the early part of the project.

The impact of alternative assumptions about the path of environmental degradation and its implication for the economics of sustainability are the subject of calculations in the following section. The analysis in this chapter concentrates on computing a private internal rate of return for various yield paths. Chapter 3 adds computations for social rates of return and a sensitivity analysis table in which a variety of policy issues and their impact on private and social IRRs can be explored.

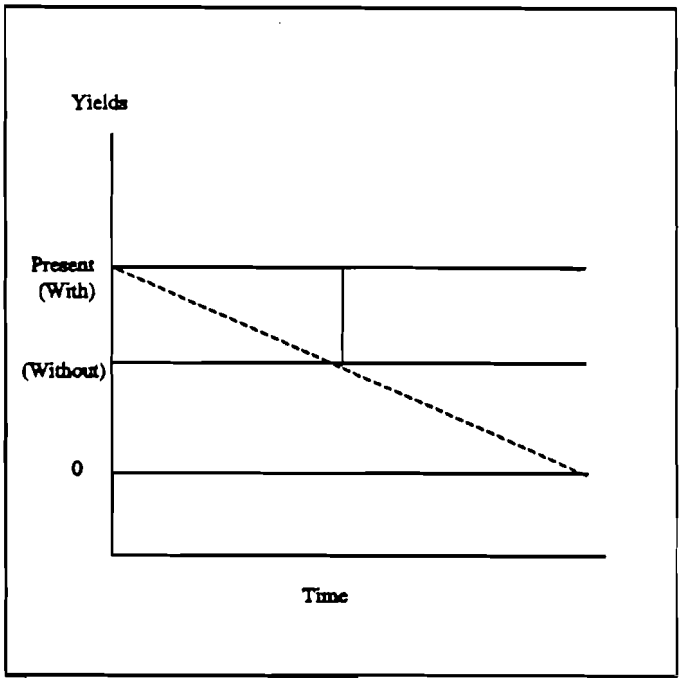


Figure 2.2: Alternative Yield Assumptions

COMPUTING A PRIVATE IRR FOR CONSERVATION MEASURES

Begin by copying the whole-farm PAM model (Chapt1.wk1) to a second file (Chapt2.wk1) that will become the base model for the private IRR calculation. The calculations involve three further tables.

Creating an "Investments" Table

Following the by now standard practice, create a table along the diamondback down and to the right of the Summary Ratios table. Although only the private values will be used in this chapter, it is efficient to create both the private and social investment components at this time. Assume, until altered by further analysis, that the numbers in the table are the same although values in the social prices table technically should be decomposed into tradables, labor, and capital, and the rules for determining the prices of each should be applied. For example, the presence of an overvalued

exchange rate in situations where machines and fuel are imported would result in a divergence between private and social investment costs.

Table 2.1 is highly simplified and can be modified later to provide more detail on costs.

Table 2.1: Conservation Investment and Maintenance Costs

	AR	AS	AT	AU
172	Invest	Investment Costs		
173			Private	Social
174				
175		Tradable Inputs (P/ha)	500	500
176		Labor (P/ha)	2,000	2,000
177	Year			
178	1	Total investment (P/ha)	2,500	2,500
179	2	Maintenance	100	100
180	3		100	100
181	4		100	100
182	5		100	100
183	6		100	100
184	7		100	100
185	8		100	100
186	9		100	100
187	11		100	100
188	13		100	100
189	14		100	100
190	15		100	100
191	16		100	100
192	17		100	100
193	18		100	100
194	19		100	100
195	20		100	100
196				

Creating a Yield Degradation Table

The analysis of alternative yield patterns requires the creation of a flexible table with which the impact on conservation IRRs of various yield paths can be explored. Table 2.2 provides such a tool. It assumes that the original technical coefficients in the input-output table are valid and do not change. The only effect of failing to make the necessary investment in conservation shown in Table

2.1 is for yields of paddy and maize to decline over time. (A more elaborate cost-benefit model is introduced in Chapter 4 in which both the with and without project input-output tables can be modified to take on alternative cropping patterns and technical coefficients.)

Table 2.2: Yield Degradation

	AW	AX	AY	AZ	BA	BB	BC
198	Yields	Yield Degradation					
199		% Yield Decline		Yields of System 1		Yields of System 2	
200		First year decline	2.0	(Without Investment)		(With Investment)	
201		Annual (%)	2.0	Paddy	Maize	Beans	Maize
202		Year					
203		1	2	2,352	1,245	2,400	1,270
204		2	4	2,304	1,219	2,400	1,270
205		3	6	2,256	1,194	2,400	1,270
206		4	8	2,208	1,168	2,400	1,270
207		5	10	2,160	1,143	2,400	1,270
208		6	12	2,112	1,118	2,400	1,270
209		7	14	2,064	1,092	2,400	1,270
210		8	16	2,016	1,067	2,400	1,270
211		9	18	1,968	1,041	2,400	1,270
212		10	20	1,920	1,016	2,400	1,270
213		11	22	1,872	991	2,400	1,270
214		12	24	1,824	695	2,400	1,270
215		13	26	1,776	940	2,400	1,270
216		14	28	1,728	914	2,400	1,270
217		15	30	1,680	889	2,400	1,270
218		16	32	1,632	864	2,400	1.270
219		17	34	1,584	838	2,400	1,270
220		18	36	1,536	813	2,400	1,270
221		19	38	1,488	787	2,400	1,270
222		20	40	1,440	762	2,400	1,270
223							

Flexibility is built into the table by making it possible to set both the initial percentage yield decline in the first year and the increment in each subsequent year. The percent degradation in Year 1 is therefore simply the cell address of the number associated with "First year" decline. For Year 2, the formula is the cell address of Year 1 plus the cell address of the number associated with the "Annual" label.

The formula for Year 2 is copied in all of the remaining cells of the time period, i.e., until Year 20. (Be sure to make the cell address for the "Annual" increment an *absolute* address before copying. The cell address for each succeeding year should reference the year that precedes it, something that is accomplished with a *relative* cell address. The formula for each year should reference the same "Increment" address and hence this term requires an *absolute* value.

The with project yields for each of the commodities are obtained by simply referencing the appropriate cell address in the I-O table. Remember to make this an *absolute* address before copying it to all time periods. This is because every period references the same cell in the I-O table.

The without yields are obtained by multiplying the with yields by one minus the cell address of the percent yield decline in each year. Thus, the without project yield in the first year is 98 percent of the with project yield. In the second year, the yield declines to 96 percent of the with project yield, etc. The formulas may be copied into all time periods using *relative* cell addresses. (Each cell is obtained by multiplying a term in its own row, e.g., 1 - the percentage yield decline times the with project yield in that same row.)

Table 2.2 can be used to simulate a wide variety of "degradation" scenarios. For example, the conventional with and without project approach referred to earlier is obtained by setting the initial percentage decline to the difference assumed in the cost-benefit analysis, e.g., 40 percent, and setting the increment equal to 0. The result will be that all without project yields will be reduced by 40 percent from Year 1 onward. (Verify that this is indeed the case.)

Creating the IRR Calculation Table

The IRR calculations shown in Table 2.3 are carried out using information from (a) the whole-farm budgets, (b) the conservation investment table, and (c) the yield degradation table. The computations can be organized in several steps:

Step 1:

The private investment cost column is obtained by referencing the appropriate cell address in the investment table and multiplying that times the total farm size obtained from the I-O table. Remeber to make the farm size address and absolute address. Only the first cell need be entered. The remaining cells in the column can be obtained by copying the first cell into each time period using the normal relative cell address for the investment table.

Step 2:

The without project revenues are obtained by using the without project yields in the yield degradation table. For private prices, the formula for each crop should reference the private prices table. Revenues for paddy would be:

Yield x Price x Hectares = Revenue from paddy

The same formula should be used to compute the revenues from maize. Total revenues shown in the without project case are the sum of the two. Before copying the formula into the remaining

Table 2.3: Private IRR Calculation

	BE	BF	BG	BH	BI	BJ	BK
230	IRR	IRR at Private Prices					
231		Investment		System 1		System 2	
232				(Without Investment)		(With Investment)	Net
233		Cost	Revenues	Costs	Revenues	Costs	Benefits
234	Year						
235	1	5,000	15,811	13,441	16,134	13,441	-4,677
236	2	200	15,489	13,441	16,134	13,441	445
237	3	200	15,166	13,441	16,134	13,441	768
238	4	200	14,843	13,441	16,134	13,441	1,091
239	5	200	14,521	13,441	16,134	13,441	1,413
240	6	200	14,198	13,441	16,134	13,441	1,736
241	7	200	13,875	13,441	16,134	13,441	2,059
242	8	200	13,553	13,441	16,134	13,441	2,318
243	9	200	13,230	13,441	16,134	13,441	2,704
244	10	200	12,907	13,441	16,134	13,441	3,027
245	11	200	12,585	13,441	16,134	13,441	3,349
246	12	200	12,262	13,441	16,134	13,441	3,672
247	13	200	11,939	13,441	16,134	13,441	3,995
248	14	200	11,616	13,441	16,134	13,441	4,318
249	15	200	11,294	13,441	16,134	13,441	4,640
250	16	200	10,971	13,441	16,134	13,441	4,963
251	17	200	10,648	13,441	16,134	13,441	5,286
252	18	200	10,326	13,441	16,134	13,441	5,608
253	19	200	10,003	13,441	16,134	13,441	5,931
254	20	200	9,680	13,441	16,134	13,441	6,254
255						Guess	.4
256						IRR	0.31
257							

time periods, be sure to make the price and hectare addresses into *absolute* cell addresses. By fixing the row and column identification, the same address in the private prices table and the I-O table will be used in computing revenues. Only the address of the yield table will change when the formula is copied.

Step 3:

The with project revenues are computed with the same formula as the with project revenues. The only difference is that instead of referencing the without project yields in the yield degradation table, the with project revenues reference the cell address containing the with project yields.

Step 4:

The with and without cost columns are obtained from the total cost (excluding land) entry for the farming system.

Step 5:

Incremental net benefits in the final column are computed in one step with a formula that:

(a) computes net benefits in the with project case by subtracting costs from revenues,

(b) computes net benefits in the without project case by subtracting costs from revenues,

(c) subtracts without project net benefits from with project net benefits, and

(c) subtracts investment costs from with project net benefits.

The formula for the first cell can be copied into the remaining time periods using relative cell addresses because all of the entries in the formula occur on the same row. The result is a time stream of incremental net benefits.

Step 6:

The internal rate of return function in Lotus 1-2-3 is:

@IRR(interest rate, range of incremental net benefit stream)

The interest rate should be entered into a cell and its cell address entered as the first argument in the function. This is the cell address to the right of "GUESS" at the bottom of the IRR spreadsheet. The cell address in the formula is followed by a comma, after which the cell addresses of the range in the incremental net benefits column is entered. The range is set in the same way that the @SUM( ) function range is set. It can be done by moving the cursor to the first cell of the range, "anchoring" it, and then highlighting the entire column to be included in the range. Alternatively, the cell addresses can be typed in directly.

SENSITIVITY ANALYSIS

The effect of adding a time dimension to the calculation of conservation IRR's can be seen by comparing the declining yield scenario with the with and without project methodology. Under the assumption that yields decline to 60 percent of the present level, i.e., decline by 40 percent over a 20 year period, conservation expenditures shown in the investment table (Table 2.1) yield a 50

percent IRR. This is compared to a 200 percent rate of return to conservation expenditures when only a flat 10 percent level of degradation is assumed. The former is obtained in the yield degradation table by setting the starting or initial value equal to 10 percent and setting the incremental value equal to 0. (Remember to use the Windows Unsynchronized command in order to see the yield degradation table and the IRR calculation simultaneously.) The effects of different rates of decline can be obtained by varying the incremental value.

Also of interest is the impact of alternative cropping patterns on the returns to conservation. Rice is clearly the more profitably crop and hence assuming a greater area under rice increases the IRR of conservation.

CHAPTER 3: THE ECONOMICS OF SUSTAINABILITY: SOCIAL PRICES

The computations needed to find the IRR at social prices are straightforward. The following steps are involved in creating such a table and an accompanying "analysis" table:

Step 1:

Copy the IRR table along the diagonal down and to the right of the private prices table.

Step 2:

Edit the cell addresses of the investment costs so that they reference the social investment costs in the investment table. Edit the addresses of the revenue columns so that they reference the social prices table. (Note that if *absolute* cell addresses have been used for area in the private IRR table, these same addresses will appear in the copied table. These are correct and should not be changed. The only changes that are required are the cell addresses of yields and prices. The former are taken from the Yield Degradation table. They should not be absolute addresses because they must be copied into each time period. The cell addresses for private prices need to be changed to the appropriate values in the social prices table. The cell addresses in the incremental net benefit column should not require adjustment as they refer to rows in the newly created table.

Step 3:

Table 3.1 shows a suggested analysis table that can be used to explore alternative assumptions about the effect of yields, the rate of degradation, prices, and cropping patterns on private and social IRR's. Cell addresses from the sensitivity analysis table should be inserted at the appropriate points in the spreadsheet. For example, the cell addresses for the area under paddy and maize should be inserted in cells C33 and D33 of the I-O table.

Many of the results of varying the parameters of the model will be obvious. Nevertheless, it is useful to trace through the logic of the effects. For example, tilting the cropping pattern away from the high value crop clearly decreases the benefits of conservation. This points to the fact that any long term sustainability effort that involves moving to crops that are less demanding of the environment at the expense of net revenue will have little private support.

Increasing farm size has the predictable effect in increasing the returns to conservation because of the way in which investment costs have been entered into the model. Currently, the investment cost table is fixed to the farming system and is not given on a per hectare basis. Consequently, increasing farm size has the effect of decreasing the cost per acre of conservation and reclamation measures.

From a policy point of view, taxes on outputs clearly have the effect of decreasing the private IRR relative to the social IRR. This means that where agriculture continues to be taxed by overvalued exchange rates and the sale of concessionally purchased commodities from abroad, the incentive to invest in activities that sustain agriculture yields is diminished.

Table 3.1: Sensitivity Analysis

Analysis	Sensitivity Analysis Table			
		First year	Annual	
	Degradation rate	.02	.02	
		Paddy	Maize	Size
	Area	1	1	2
	Yields	2400	1270	
		Prices		
	Private	4.5	4.2	
	Social	4.7	4	
		IRR	Guess	
	Private	30.9%	0.4	
	Social	31.2%	0.4	

Undertaking conservation activities when there is a divergence between private and social IRR's e.g., private IRR's are lower than social IRR's, would require that the opportunity cost of capital with which the IRR is compared should also differ. If the social opportunity cost of capital was below the private rate, for example, it would be correct to undertake conservation measures in cases where the social IRR was below the private IRR. However, to the extent that private individuals are expected to implement these methods, a mechanism must be found to deliver to incentive in the form of a subsidy to the private sector. In the accompanying PAM, this would show up as a subsidy on capital.

CHAPTER 4: SUSTAINABILITY AND ALTERNATIVE FARMING SYSTEMS

The previous exercises in the economics of conservation focused on a farming system in which the commodities grown did not change and only the yields responded to conservation investments. The result showed that a variety of policy issues--along with assumptions about the path of yield degradation--had a significant effect on the economics of conservation investments.

True "sustainability," however, often requires more than erosion control or drainage measures. With the additional constraint of sustainability, optimal cropping patterns are affected and new crop new combinations of crops are likely to emerge in response to changes in private incentives. The following exercise simulates the use of a second farming system in the sustainability analysis. In it beans replace paddy. The new beans-maize system is designated as the with project case.

ADDING A SECOND FARMING SYSTEM

There are a variety of ways in which a second farming system might be added including creating a new I-O table and the associated private and social budgets along the diagonal. However, there are substantial efficiencies to be gained if the second farming system is incorporated in the existing tables by *inserting* additional columns. Many of the formulas can then simply be copied from the existing columns to new columns that have been relabeled to indicate that they belong to a second farming system.

Creating the I-O Table

Table 4.1 shows how the I-O table would look after a second farming system has been added. To create the table, move the cursor into the column to the right of the last column in the original table. *Insert* three columns. Copy the three existing columns into the space created by the blank columns just inserted. Relabel the "paddy" column and call it "beans." (Note: Data in the area column copies over as a zero. Insert 1's in the cell addresses for land and the columns will compute their correct values. Also, type in yields from the previous columns in order to obtain values for commodity output. For starters, keep the data in the paddy column intact. This will make it possible to check the accuracy of the entire spreadsheet before turning to the question of how the new farming system differs from the old.

Creating the Private and Social Prices Tables

Create the new private and social prices tables with a similar procedure. Move the cursor to the column to the right of the last column in the table. *Insert* two additional columns in each table and copy the existing columns into the newly created columns.

Creating Private and Social Budgets

Creating the budget tables also follows the procedure outlined above. Move the cursor to the right of the last column of the table and *insert* three columns. Copy the existing columns into the newly created columns.

Table 4.1: Input-Output Table: Whole Farm PAM

	A	B	C	D	E	F	G	H
1	I-O	Input-Output Table	W/O Investment		Farming	With Investment		Farming
2			Paddy	Maize	System1	Beans	Maize	System2
3								
4	Tradables:	Fertilizer (kg/ha)						
5		Urea	167	85	252	167	85	252
6		0-18-0	20		20	20		20
7		Chemicals (kg/ha)	2	.5	2.5	2	.5	2.5
8		Seed (kg/ha)	115	40	155	115	40	155
9		Fuel (liter/ha)						
10								
11	Factors:	Labor (P/man-hr)						
12		Seedbed preparation	65	50	115	65	50	115
13		Crop care	100	100	200	100	100	200
14		Harvesting	200	180	380	200	180	380
15		Threshing	5	0	5	5	0	5
16		Shelling	0	60	60	0	60	60
17		Drying	60	20	80	60	20	80
18								
19		Capital						
20		Working capital	3398	1630	5028	3398	1630	5028
21		Tractor services	140	120	260	140	120	260
22		Thresher (P/hr)	40	0	40	40	0	40
23								
24		Land (ha)	1	1	2	1	1	2
25								
26		Yields (kg/ha)	2405	1270		2405	1	
27		Output (total kgs)	2405	1270		2405	1270	
28	==========	==========	==========	==========	==========	==========	==========	==========
29								

Recall that values in the cells of the budget tables are obtained by multiplying prices times the quantities in the prices tables. Because of the intervening "Totals" column in the I-O table, the cell addresses in the newly created section of the budget tables must be edited. Specifically, the column addresses shown in the newly created columns need to be advanced by one letter. If the column address in the total revenues cell of beans, for example, reads E, it should be advanced to F. The adjacent maize budget column should be edited to reflect the maize output column, G.

The total commodity cost calculations should be computed properly without adjustment. They refer to the rows in the column of the calculations and the normal relative cell address adjustments should have been made. The total farm revenues and costs also require some editing.

Revising the Yield Degradation Table

Adding the new farming system to the yield degradation table is straightforward. Two new columns are required to hold the with and without data on bean yields. The old cell addresses for the without case can be retained; they refer to Farming System 1 which is the without project case.

Since there is no paddy in the new with project case, paddy yields should be set to 0. Similarly, because beans do not appear in the without project case, their yields should be set to 0. The with project bean yields should reference the yields in the I-O table. (Setting these yields to 0 is not significant since these cell addresses do not appear in the IRR table. However, when set to 0, they serve as a reminder that the two farming systems do not contain the same crops.)

The with project maize yields should be adjusted to reflect maize yields in Farming System 2; in the without case, the reference continues to be Farming System 1 and need not be adjusted.

Revising the IRR Tables

The revisions in the IRR table are two-fold. First, the cell addresses that describe the with project case need to be changed so that the area, yields and prices of the with project case reflect bean yields instead of paddy yields. Second, the cost figures for beans need to be substituted in place of the cost figures for paddy in the with project case. The without project revenues do not require adjustment.

Step 1:

In the with project case, substitute the area, yield and price of beans. Also, change the cell address of area and yield in the maize revenue calculation to reflect maize in Farming System 2.

Step 2:

Adjust the with project cost cells to reflect the area under beans and maize in Farming System 2 and the costs of beans and maize in the Farming System 2 section of the private and social budgets.

Edit the with project cell address for revenues so that the elements refer to the area, yield and price of beans instead of paddy. (The maize cell addresses should also be changed to reflect maize grown in Farming System 2 rather than maize in Farming System 1.

Expanding the Analysis Table

The final step in creating a more flexible "sustainability" template is to include the second farming system in the analysis table. Table 4.3 shows the revised table. The new cell addresses for beans and maize under Farming System 2 should be added at the appropriate places in the I-O table

Table 4.2: Yield Degradation

Yields	% Yield Degredation		Yields of System 1		Yields of System 2	
	First year (%)	2.0	(Without Investment)		(With Investment)	
	Annual (%)	2.0	Paddy	Maize	Beans	Maize
	Year					
	1	2	2,352	1,245	2,400	1,270
	2	4	2,304	1,219	2,400	1,270
	3	6	2,256	1,194	2,400	1,270
	4	8	2,208	1,168	2,400	1,270
	5	10	2,160	1,143	2,400	1,270
	6	12	2,112	1,118	2,400	1,270
	7	14	2,064	1,092	2,400	1,270
	8	16	2,016	1,067	2,400	1,270
	9	18	1,969	1,041	2,400	1,270
	10	20	1,920	1,016	2,400	1,270
	11	22	1,872	991	2,400	1,270
	12	24	1,824	965	2,400	1,270
	13	26	1,776	940	2,400	1,270
	14	28	1,728	914	2,400	1,270
	15	30	1,680	889	2,400	1,270
	16	32	1,632	864	2,400	1,270
	17	34	1,584	838	2,400	1,270
	18	36	1,536	813	2,400	1,270
	19	38	1,488	787	2,400	1,270
	20	40	1,440	762	2,400	1,270

Table 4.3: Sensitivity Analysis of Conservation Returns

Analysis	Sensitivity Analysis Table				
		First year	Annual		
	Degradation rate	.02	.02		
		Farming System 1		Farming System 2	
		Paddy	Maize	Beans	Maize
	Area	1	1	1	1
	Yields	2400	1270	2400	1270
		Prices			
	Private	4.5	4.2	4.5	4.2
	Social	4.7	4	4.7	4
		IRR	Guess		
	Private	31.9%	.4		
	Social	31.2%	.4		

and the calculated IRRs should be inserted in the analysis table so that the effects of changing data in the upper part of the table on the IRR's can be seen immediately.

ANALYZING SUSTAINABILITY SCENARIOS

When beans are given the same input-output values and prices as paddy, the new template reproduces the results of the template developed in the previous chapter. Using the same values provides a useful check on the accuracy of the template's construction. However, adding an additional farming system has, as it purpose, the investigation of more complex issues of sustainability than could be done with the template developed in Chapter 3. Examples include the following:

(1) Separating the with and without project farming systems makes it possible to examine the economics of radical changes in the way in which commodities are produced. Crops grown under the new regimes may have a distinction different set of I-O coefficients. Minimum tillage practices, for example, often generally result in somewhat lower yields, but costs are also reduced significantly leading to an overall increase in net revenues.

(2) With a second farming system table, it is also possible to capture the effects of yield enhancing investments. Terracing, for example, is often a poor investment if the objective is simply to maintain existing yields. However, if terracing can open the way toward a better utilization of water and even the use of chemical fertilizers, the result may be an IRR that would be of interest to private entrepreneurs.

CHAPTER 5: COMBINING DEVELOPMENT AND SUSTAINABILITY

In the previous appraisal, the economics of maintaining productivity were explored. Benefits from the project or policy were due to the difference between the continuation of current yields and the decline in yields that would have occurred had the project or policy not been implemented. While some of the conclusions drawn from these calculations are rather pessimistic in the sense that use of more realistic time-related deterioration of the resource base reduces the returns to conservation, there is also a potential benefit from incorporating sustainability considerations in all project appraisal efforts.

Figure 5.1 suggests a situation in which the benefits from the project flow, not only from arresting resource degradation, but from enhancing productivity as well. One could imagine a number of projects that fit this type of model. Terracing, for example, may be important in arresting water erosion. However, as noted in Chapter 4, it also makes possible greater control over moisture and hence the use of purchased inputs that would otherwise be very risky. Use of vertical drainage is another example. In this type of project, tubewells are put down to pump groundwater for use in irrigation, a practice that lowers the water table at the same time that it provides additional water for irrigation.

INCORPORATING YIELD ENHANCEMENT

The possiblities for yield enhancement can be incorporated in the same way that yield degradation was incorporated (Table 5.1) The only difference is a change in sign. In the enhancement mechanism, the with project yields are measured by one plus the enhancement percentage rather than one minus the enhancement rate.

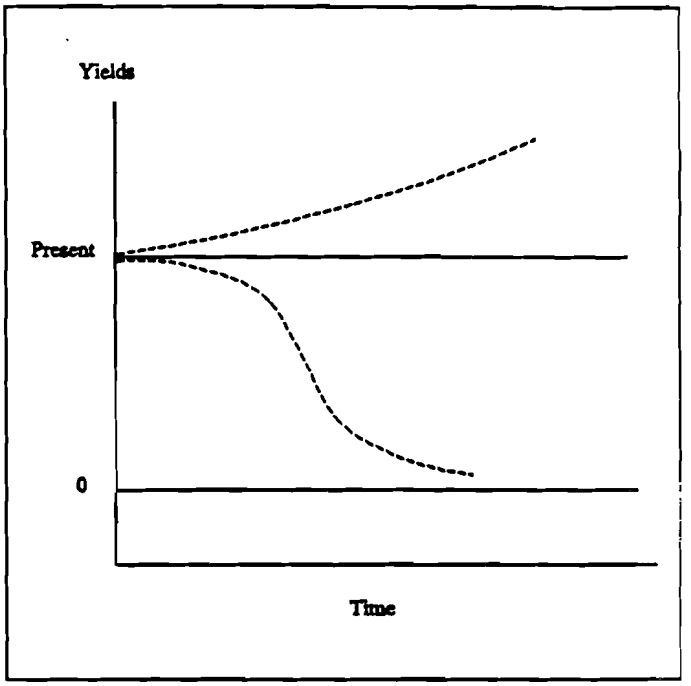


Figure 5.1: Yield Enhancing Sustainability

The enhancement rate is also incorporated in the analysis table. It is always important to remember that, from a benefit-cost point of view, the project IRR is determined by the difference between the with and without cases. It matters not whether the increment is secured by an increase of one percent per annum in yields in the with case or by a one percent decrease in yields in the without case. The all important number is the difference between the two. Hence, any project that simultaneously increases output while minimizing the deterioration of the resource base need not be delayed until severe degradation sets in to be economically viable. In the long run, the effort to create a sustainable agriculture will benefit from the search for projects and policies that have the characteristics shown in Figure 5.1

Table 5.1: Yield Degradation

Yields		Degredation	Enhancement	Yields of System 1 (Without Investment)		Yields of System 2 (With Investment)	
	First year change (%)	2.0	0				
	Increments (%)	2.0	0	Paddy	Maize	Beans	Maize
	Year						
	1	2	0	2,352	1,245	2,400	1,270
	2	4	0	2,304	1,219	2,400	1,270
	3	6	0	2,256	1,194	2,400	1,270
	4	8	0	2,208	1,168	2,400	1,270
	5	10	0	2,160	1,143	2,400	1,270
	6	12	0	2,112	1,118	2,400	1,270
	7	14	0	2,064	1,092	2,400	1,270
	8	16	0	2,016	1,067	2,400	1,270
	9	18	0	1,969	1,041	2,400	1,270
	10	20	0	1,920	1,016	2,400	1,270
	11	22	0	1,872	991	2,400	1,270
	12	24	0	1,824	965	2,400	1,270
	13	26	0	1,776	940	2,400	1,270
	14	28	0	1,728	914	2,400	1,270
	15	30	0	1,680	889	2,400	1,270
	16	32	0	1,632	864	2,400	1,270
	17	34	0	1,584	838	2,400	1,270
	18	36	0	1,536	813	2,400	1,270
	19	38	0	1,488	787	2,400	1,270
	20	40	0	1,440	762	2,400	1,270

Table 5.2: Sensitivity Analysis of Conservation Returns

	Sensitivity Analysis Table				
	Investment (P/ha)	Initial	Maintenance		
	Private prices	100%	100%		
	Social prices	100%	100%		
		First year	Annual		
	Degredation rate	.02	.02		
	Enhancement rate	.00	.00		
		Farming System 1 (without)		Farming System 2(with)	
		Paddy	Maize	Beans	Maize
	Area	1	1	1	1
	Yields	2400	1270	2400	1270
		Prices			
	Private	4.5	4.2	4.5	4.2
	Social	4.7	4	4.7	4
		IRR	Guess		
	Private	30.9%	.4		
	Social	31.2%	.4		